Series 1938, No. 11 Issued January 1948

Soil Survey

The Newman Area California

By

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

SOIL SURVEYS provide a foundation for all land use programs. The report on each survey and the accompanying map present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part. Ordinarily he will be able to obtain the information he needs without reading the whole. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers of three general groups: (1) Those interested in the area as a whole; (2) farmers and others interested in specific parts of it; and (3) students and teachers of soil science and related agricultural subjects. Attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users: (1) General Nature of the Area, in which location and extent, physiography and drainage, climate, vegetation, organization and population, transportation and markets, and cultural development and improvement are discussed; (2) Agriculture, in which a brief history and the present status of the agriculture are described; and (3) Soil Ratings, in which the soils are rated according to their potential suitability for the production of crops.

Readers interested chiefly in specific areas—as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm loan agencies. These readers should (1) locate on the map the tract with which concerned; (2) identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them; and (3) locate in the table of contents in the section on Soils the page where each type is described in detail and information given as to its suitability for use and its relations to crops and agriculture.

Students and teachers of soil science and allied subjects—including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology—will find their special interest in the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils, in which are presented the general scheme of classification of the soils of the area and a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on General Nature of the Area, Agriculture, Laboratory Studies, and the first part of the section on Soils of particular value in determining the relations between their special subjects and the soils of the area.

This publication on the soil survey of the Newman area, Calif., is a cooperative contribution from the—

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SOIL SURVEY OF THE NEWMAN AREA CALIFORNIA

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United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station

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[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

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EARLY agriculture in the Newman area consisted in raising cattle and sheep. Grain growing became important during the sixties, and as a result claims and homesteads were increasingly established. Irrigation aided in growing grain and pasture. Water-borne traffic was developed, and grain was transported to market by steamboats on the San Joaquin River. Dairy cattle were soon brought into the area, and dairying has since been a steadily growing industry, until at present it probably contributes more income than any other single enterprise, and parts of the area are among the densest dairying areas in the United States. A number of creameries, dairies, and warehouses employ several hundred men during the busiest season. The principal crops grown are beans, barley, alfalfa, grapes, and tree fruits. To provide a basis for the best agricultural uses of the land a cooperative soil survey was begun in 1938 by the United States Department of Agriculture and the University of California Agricultural Experiment Station. The essential features may be summarized as follows.

SUMMARY

More than half of the Newman area consists of the valley floor and alluvial fan slopes that comprise most of the agricultural land. The western part consists of upland old alluvial terrace, foothill, and mountainous areas used mainly for grazing cattle and sheep.

The soils of the hilly and mountainous uplands include types and phases of the Gaviota, Altamont, Diablo, Kettleman, Crow Hill, and Vallecitos series. They are used mainly for grazing. The soils of the recent alluvial fans include the Mocho and the Sorrento series. These are extensive and important and are well suited to a wide range of irrigated field and orchard crops. The soils of the young alluvial fans—the Zamora and Dublin series—have subsoils that are slightly more compact than the surface soils. Normally this condition is associated with a little better moisture holding capacity. Of these the Zamora soil, which is of heavy texture and blocky structure, is the more important.

Soils developed on older alluvial fans include the Esparto, Pleasanton, Ambrose, Rincon, and Herdlyn series. These have somewhat heavier textured and more compact subsoils and are not adapted to so wide a range of crops, but they are good general farming soils. Soils of more strongly developed profile underlain by compact or dense subsoils occupy the old alluvial terraces. They are usually without water supply for irrigation and are used mainly for pasture and to some extent for dry-farmed grain. This group includes the soils of the Denverton, Positas, and Ohmer series. The alluvial soils of the flood plains and basins include the Orestimba, Columbia, Dinuba, Sacramento, and Merced series. They are subject to overflow or generally occur under conditions of poor drainage, but where protected from overflow and improved by drainage are productive and used for a wide variety of crops.

The soils fall into six natural groups, based on physiographic position and degree of soil profile development.

Because of overgrazing and faulty range management some of the soils of the steeper upland foothill and mountain slopes have been moderately to severely eroded. Accelerated erosion on the irrigated valley lands is practically negligible.

About half the area within the valley is under irrigation. A few areas of accumulated alkali, or salts, occur, mainly in low-lying areas adjacent to the San Joaquin River and principally in soils of the Orestimba and Merced series.

The soils are classified with respect to potential and actual suitability for crops and land use. Laboratory studies of some of them were made at the University of California.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

The Newman area, covering 293 square miles, or 187,520 acres, is in Stanislaus County on the west side of the northern San Joaquin Valley (fig. 1). It includes all of the valley part of the county west of the San Joaquin River and a part of the hilly lands to the west. Much of the area is included in the earlier soil survey of the Lower San Joaquin Valley.[2]

The area is roughly rectangular, and extends in a northwesterly direction from the Stanislaus-Merced County line on the south to the Stanislaus-San Joaquin line on the north.

PHYSIOGRAPHY AND DRAINAGE

The area consists of three parallel natural physiographic belts or divisions: (1) The mountainous and foothill areas that form the western boundary and roughly parallel the San Joaquin River, which forms the eastern boundary; (2) a broad central valley plain consisting of smooth confluent alluvial fans built up by small streams flowing from the hills on the west; and (3) the narrow flood plain of the San Joaquin River on the east.

[2] NELSON, J. W., GUERNSEY, J. E., HOLMES, L. C., and ECKMANN, E. C. RECONNAISSANCE SOIL SURVEY OF THE LOWER SAN JOAQUIN VALLEY, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. (1915) Rpt 17: 2583–2733, illus. 1919.

The mountain and foothill areas are composed of sandstone, shale, and conglomerate rocks with a soil mantle of variable thickness. With these are associated remnants of old elevated alluvial terraces, the material of which forms only a thin mantle over bedrock. In

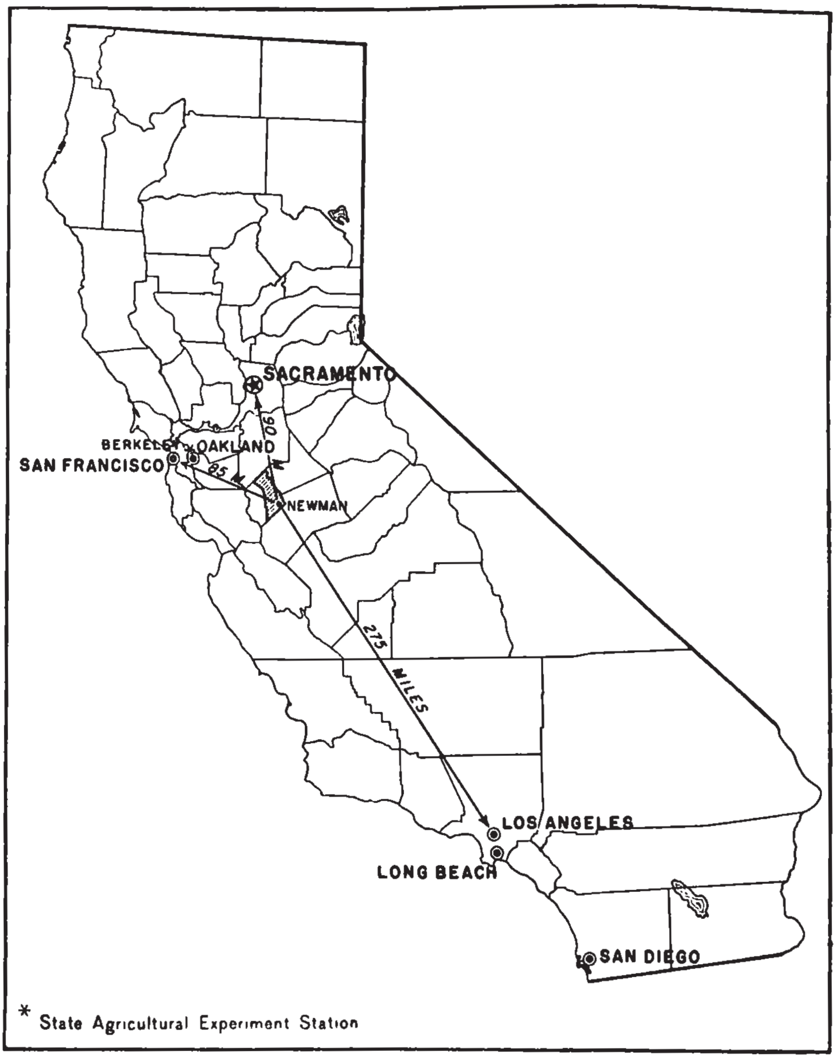

FIGURE 1.—Location of Newman area in California.

such areas the tops of the broad terrace remnants have soils developed on the old unconsolidated terrace materials, while the slopes have soils developed on bedrock of shale, sandstone, or conglomerate into which gullies and stream channels have cut. These terraces seldom occur at elevations in excess of 600 feet, and usually begin at 125 to 175 feet.

The mountainous areas, which rise to elevations of 1,500 to 1,600 feet to the west of these terraces, are dominated by a succession of ridges extending nearly parallel to the major axis of the San Joaquin Valley. These are incised at almost right angles by Garzas, Orestimba, Crow, Puerto, and Ingram Creeks with minor channels extending back between the ridges. The eastern slopes are more gentle than the western, along which in many places outcrops of shale, sandstone, and conglomerate bedrock occur. The rock strata are tilted toward the east, although not uniformly. The southern part of the area extends farther into the hills than the northern, and here the rocks are harder and are definitely metamorphosed. These areas are covered by trees on the eastern and northern slopes and by grass and brush on the southern and western slopes. The mountainous areas to the north are covered with grass and scattered shrubs. Woodland pastures are used principally for cattle, and areas in grass for sheep. Some of the lower and flatter parts of the terraces are used for dry-farmed grain as well as for pasture land for sheep.

The valley plain is the most extensive of the three physiographic divisions and the most important agriculturally. This division consists of a broad, smooth plain 4 to 8 miles wide, extending from the northern to the southern boundary of the area and running parallel to the San Joaquin River. The plain is made up of a series of confluent alluvial fans formed by a number of minor streams emerging from the hills on the west. None of these streams flows continuously and all are dry part of the year. Practically all of them rise westward of this area. Most of the stream channels disappear on the alluvial fans, where their waters are soon lost through percolation and seepage. Orestimba Creek is the only stream large enough to maintain a definite channel across its fan to the San Joaquin River. A wide variety of field, orchard, and truck crops can be grown under irrigation in a large part of the valley plain, but the water supply for the rest is inadequate. All the towns and practically all the population are within this belt.

The narrow flood plain of the San Joaquin River is confined to the trough of the valley and is seldom more than 1 mile wide and usually much less. Under natural conditions this plain is subject to annual overflow during seasons of high water. The soils are normally covered by willows and cottonwood trees and traversed by many small winding sloughways and natural channels. The water table is normally high and in many places artificial drainage is necessary before the land can be farmed. Areas now under cultivation in this belt are protected from overflow by levees. Normally these levees are adequate, but the extremely high water of the spring and summer of 1938 overflowed most of them and flooded practically all the flood plain within the area. The soils are usually highly productive and suitable for many field and truck crops but not for orchards or vineyards. Some are affected by salts and in the southeastern part a few areas are underlain by fragments or remnants of an old silica-cemented hardpan.

CLIMATE

The climate of the Newman area is typical of that of the Great Valley and most of the interior valleys of California. It is characterized

by hot rainless summers with low humidity and cloudless skies, and cool rainy winters with high humidity and dark rainy and cloudy periods interspersed with mild sunny days. Some fogs occur in winter, especially in the lower areas. These usually start late in the evening and though generally dispersed late in the forenoon they sometimes continue throughout the day. Damaging winds are not very common; although some moderately severe ones blow from the northwest in winter. An occasional wind late in spring may do some damage to fruit trees improperly pruned and thinned.

About 80 percent of the year's total rainfall occurs from November to March. This rainy season has periods of 3 or 4 days in which gentle rains are interspersed by bright clear days with mild temperatures. From Newman north to Tracy there is very little difference in rainfall and other climatic factors, but the precipitation decreases rapidly to the south, Los Banos receiving only about 80 percent as much as Newman.

The mean monthly and annual precipitation for a number of Weather Bureau stations in this general area are given in table 1.

TABLE 1.—*Mean monthly and annual precipitation at several stations in and near the Newman area, Calif.*[1]

Month	Tracy	Westley	Newman	Modesto	Los Banos
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
January	1 96	2.43	2 15	2 20	1 91
February	1 39	1.52	1 66	2.01	1.33
March	1 71	1 93	1 80	1.75	1.43
April	.85	.69	.66	.76	.61
May	.58	.61	44	.51	.46
June	15	09	05	17	05
July	.01	.02	01	0	0
August	.01	(2)	01	.03	.01
September	19	.17	.22	.15	.13
October	47	.47	43	46	.32
November	1 06	1.03	1 06	1 23	90
December	1 88	1.79	1 75	1.76	1.32
Annual	10 26	10 75	10 24	11 03	8.47

[1] Data from U. S. Weather Bureau records.
[2] Trace.

The mean annual temperature of this area is approximately 63° F. July is the hottest month (mean, about 80°) and January the coldest (mean, about 46°). The maximum temperature recorded in Newman and Westley is 115°, and the lowest is 17° at Newman and 20° at Westley. Summer temperatures exceeding 110° and winter temperatures below 27° are rare. The earliest killing frost recorded at Newman is October 18, and the latest spring frost is May 20, with average dates of November 22 and March 6, or an average of 261 frost-free days. Los Banos, just south of this area, is influenced by warmer winds coming through the Pacheco Pass to the west and has an average of 288 (Feb. 12 to Nov. 27) frost-free days. The maximum, minimum, and mean monthly and annual temperatures for stations in and near the Newman area are given in table 2.

TABLE 2.—*Maximum, minimum, and mean monthly and annual temperatures (degrees Fahrenheit) of several stations in and near the Newman area, Calif.*[1]

Month		Tracy	Westley	Newman	Modesto	Los Banos
January	Maximum	72	75	72	81	81
	Minimum	18	20	17	22	20
	Mean	46.8	46.0	46.4	44.2	48.2
February	Maximum	82	79	84	92	77
	Minimum	26	26	19	24	25
	Mean	50.6	52.1	51.3	49.2	50.8
March	Maximum	82	85	91	87	80
	Minimum	30	32	27	32	30
	Mean	54.4	56.7	55.5	54.5	55.7
April	Maximum	94	94	08	95	98
	Minimum	36	40	28	30	40
	Mean	60.6	63.9	60.9	59.2	62.0
May	Maximum	103	105	106	105	100
	Minimum	40	38	30	38	45
	Mean	68.8	70.2	67.5	65.6	67.8
June	Maximum	106	109	109	108	106
	Minimum	50	50	38	43	52
	Mean	75.6	77.6	74.7	71.6	74.4
July	Maximum	114	115	115	111	110
	Minimum	56	50	41	47	55
	Mean	79.9	82.4	79.8	75.9	79.8
August	Maximum	115	113	114	111	110
	Minimum	51	50	34	48	56
	Mean	77.5	79.3	77.9	74.3	78.5
September	Maximum	107	107	112	110	106
	Minimum	48	50	39	41	50
	Mean	72.4	74.1	72.2	69.5	73.0
October	Maximum	93	94	99	106	92
	Minimum	40	32	30	33	40
	Mean	64.3	67.0	64.4	62.5	64.7
November	Maximum	80	82	90	90	84
	Minimum	25	26	17	26	28
	Mean	54.6	56.3	53.5	52.2	54.9
December	Maximum	76	71	82	84	80
	Minimum	18	20	18	15	24
	Mean	47.6	48.5	46.7	45.4	48.1
Annual	Maximum	115	115	115	111	110
	Minimum	18	20	17	15	20
	Mean	62.8	64.5	62.6	60.3	63.2

[1] Data from U S Weather Bureau records.

VEGETATION

Native vegetation occurs principally in the hills and mountains of the western part of the area. In general there is a zone of grassland just above the valley floor and on the low rolling foothills of the Diablo Range. Farther west and on the higher and steeper slopes the grassland gives way to woodland-grass or brush associations.

Grasses and associated herbs occur on all the upland soils, but they predominate in the Kettleman, Diablo, Crow Hill, and Denverton series and on Altamont clay (adobe). Slender oat and soft chess are the most abundant grasses, and alfileria, peppergrass, and owlclover are among the abundant associated herbs. In general, slender oat predominates on the low foothills adjacent to the valley floor, and soft chess on the higher slopes to the west. Brush, mainly California sagebrush, occurs on some of the very steep slopes and shallow soils in grassland areas. Such areas adjacent to the valley floor are used mainly for sheep grazing.

A woodland-grass association occupies relatively small areas on the higher and steeper slopes of the Diablo Range, mostly in the southwestern parts on steep slopes of the Vallecitos, Altamont, and Gaviota soils. In general the woodland-grass association consists of open stands of trees with intervening spaces of grasses and herbs and is used mainly for grazing beef cattle. California blue oak and digger pine are the principal trees, and soft chess the principal grass.

Brush, chiefly chamise and big sagebrush, occupies some southern exposures of upland soils that are very steep and shallow. Chamise occurs mainly in the southwestern parts associated with woodland-grass, and sagebrush mainly in the northwestern parts associated with grassland and on soils of the Kettleman series. In the northwestern part the big sagebrush lies between grassland and a small zone of piñon pine-juniper outside the area to the west.

The following are some of the important trees, shrubs, herbs, and grasses in the area:

TREES

Pinus sabiniana Dougl	Digger pine.
Quercus douglasii Hook. and Arn	California blue oak.

SHRUBS

Adenostoma fasciculatum Torr	Chamise.
Artemisia tridentata Nutt	Big sagebrush.
Eriogonum fasciculatum Benth	Flat-top buckwheatbrush.
Prunus ilicifolia (Nutt.) Walp	Hollyleaf cherry.

HERBS

Achyrachaena mollis Schauer	Blowwives.
Amsinckia douglasiana DC	Buckhorn.
Athysanus pusillus (Hook.) Greene	
Baeria spp	Goldfields.
Brodiaea laxa (Benth.) S. Wats	Grass nut.
Calandrinia caulescens H B K	Rockpurslane
Capsella bursa-pastoris (L) Medic	Shepherds-purse.
Erodium botrys Bertol	
Erodium circutarium (L.) L'Her	Alfileria.
Erodium moschatum (L.) L'Her	Heronbill.
Eschscholtzia californica Cham	California-poppy.
Galium aparine L	Goosegrass.
Gilia tricolor Benth	Birdseye.
Godetia spp	Godetia.
Grindelia robusta Nutt	Gumweed.
Gutierrezia spp	Snakeweed.
Hemizonia kelloggii Greene	Tarweed.
Hemizonia virgata A. Gray	
Lepidium nitidum Nutt	Peppergrass.
Lotus scoparius (Nutt.) Ottley	Deervetch.
Lotus subpinnatus Lag	Birdsfoot trefoil.
Lupinus bicolor Lindl	Lupine.
Marrubium vulgare L	Horehound.
Microseris douglasii (DC.) Sch. Bip	
Orthocarpus purpurascens Benth	Owlclover.
Plagiobothrys tenellus A Gray	Popcorn flower
Plantago erecta Morris	Plantain.
Stellaria nitens Nutt	Chickweed
Trifolium gracilentum Torr. and Gray	Pin-point clover.
Trifolium variegatum Nutt	White-point clover.

GRASSES

Avena barbata Brot	Slender oat.
Bromus mollis L	Soft chess.
Bromus rubens L	Foxtail chess.
Distichlis spicata (L.) Greene	Seashore saltgrass.
Festuca spp	Fescue.
Hordeum murinum L	Mouse barley.
Koeleria phleoides (Vill.) Pers	
Melica bulbosa Geyer	Oniongrass.
Poa scabrella (Thurb) Benth	Pine bluegrass.
Stipa pulchra Hitchc	Purple needlegrass.

ORGANIZATION AND POPULATION

The population of Stanislaus County has grown rapidly since 1900, when it was 9,550, to 74,866 in 1940. The entire west side of the county was included in Newman Township until after 1910 when the Patterson Colony was organized. As the population at Patterson increased, Newman Township was divided into the Newman and Patterson Townships. Newman in the southern part and Patterson in the central part are the only towns in this area with a population of more than a few hundred. Other small towns are Grayson, Westley, and Crows Landing.

TRANSPORTATION AND MARKETS

The west-side branch of the Southern Pacific Company, connecting with the main line of its valley route at Tracy and Fresno, furnishes freight and passenger service to outside areas and markets. The west-side highway running parallel to the railroad and a number of county roads to communities on the east side of the valley furnish a good highway system for travel and for transportation of commodities.

Most of the residents are engaged in agriculture or agricultural industries. A number of creameries, dairies, and warehouses employ several hundred men during the busiest season. The El Solyo Ranch, a 4,600-acre irrigated ranch doing diversified farming and operating a packing plant and dehydrator, employs 400 workers throughout the year and as many as 900 during the busiest season. The seasonal harvesting of winter peas, fruits, and other crops attracts 2,500 to 3,000 migratory workers annually. A considerable number of people are employed on grain and bean farms, as handlers for sheep and cattle raised, and in various types of mercantile enterprises catering to the daily needs of residents of the area.

CULTURAL DEVELOPMENT AND IMPROVEMENT

Primary schools are maintained in Westley, Patterson, Crows Landing, and Newman; a rural school just south of Vernalis in San Joaquin County; and high schools in Newman and Patterson. These schools are modern and well equipped, and free bus transportation is furnished school children living in rural districts.

Recreational features are varied and numerous. City parks and recreational features are available in Newman and Patterson, and Patterson has an excellent community swimming pool. Theaters, fraternal organizations, and churches provide adequately for the social and religious needs of most of the people.

AGRICULTURE

HISTORY AND PRESENT TRENDS

In the early forties, of several Mexican land grants made in the San Joaquin Valley, three were very important with respect to the settlement of the area. They were known as El Pescadero in the northern part and extending northward into San Joaquin County, Rancho del Puerto in the central part, and Orestimba Rancho in the southern

part extending southward outside. The holders of these grants had a few cattle but did little or no farming.

In 1849 a party of men built a ferry to cross the San Joaquin River at Grayson, and shortly afterward Jesse Hill built one at Hills Ferry. These two places grew to small settlements and were stagecoach stops on a route connecting with Banta in San Joaquin County. Isaac Crow came to this section about 1850 and he and several brothers located on the San Joaquin River near the mouth of Orestimba Creek, where they found excellent pasture for their sheep, cattle, and mules.

Early in the fifties the Mexican land grants were purchased by incoming settlers, who began raising cattle and sheep. The sheep were herded after a fashion but the cattle roamed the plains and hills from Tulare Lake to Antioch. At periodic round-ups the young livestock was branded and returned to the range. The cattle were raised mostly for hides and tallow but soon a ready market for meat developed in the mining camps of the Sierra Nevada foothills.

Grain growing became important during the sixties and resulted in establishing many claims and homesteads. Grain farmers were continually having trouble with livestock owners because neither farms nor the range were fenced. In 1870 the State of California passed a law requiring owners either to fence in their livestock or to pay damages to farmers for crops injured. This law was in effect from northern California to the Calaveras River, and in 1873 was extended to include Stanislaus and Merced Counties, which greatly expanded grain farming.

With the increase in grain farming water-borne traffic was developed and grain was transported to market by steamboats on the San Joaquin River. Grayson and Hills Ferry became important towns along the river. The high-water period of the San Joaquin, from the latter part of May to early in June, brought about by melting snow in the high Sierras, followed so closely the grain harvest season that it was often difficult to get the grain shipped by boat before navigation became dangerous.

By 1876 Henry Miller, who then owned large holdings in that section, built a canal from Mendota in Fresno County to Los Banos in Merced County, and a year or two later extended it a few miles north of Orestimba Creek. The canal was projected mainly for transportation, but as irrigation was begun about that time it was used for that purpose. At present it is still used for irrigation purposes and furnishes water to lands below its ditch from Mendota to Crows Landing.

Dairy cattle were brought into the area in the early seventies, and dairying has since been a steadily growing industry. At first the irrigation water was used mainly for grain or pasture, but alfalfa was soon introduced and this crop has increased in step with the dairy industry, until now the area between Newman and Patterson is one of the densest dairy-cow areas in the United States, and alfalfa hay is the principal cattle feed used.

In 1888 the town of Newman was founded and named in honor of Simon Newman, who was the leading merchant of Hills Ferry and was influential in having the railroad extended from Tracy in San Joaquin County. With the advent of the railroad, the town of Hills Ferry was moved to Newman.

The people north of the canal continued growing dry-farmed grain until about 1909, when the Patterson Colony was organized and the

town of Patterson was founded. This colonization was promoted by the heirs of John D. Patterson, who obtained most of the land in the Mexican grant of Rancho del Puerto. A tract of about 19,000 acres was subdivided into about 30-acre farms, with roadways laid out at half-mile intervals.

The first purchasers of land in the colony were mostly Scandinavians from the Midwest, some of whom are still on their holdings, though many were unable to farm this land successfully, as most of the holdings were too small to support a family. In many instances two or three turn-overs have been made and at present most of the units contain 40 to 60 acres. Water rights were sold with the land, and definite water assessments are charged to each acre within the district. Dairying and fruit farming are the principal enterprises within the Patterson Colony, with small acreages planted to beans and other field crops, but alfalfa is grown on the larger farms. A few of the more important crops and agricultural enterprises are discussed below.

FIELD CROPS

BEANS

The acreage planted to beans has steadily increased in the past 15 years until at present this crop has become one of the most extensively cultivated crops in the area; the 1939 Federal census of Stanislaus County shows a total of 35,448 acres. Much of this is in baby limas, with the rest divided between black-eyed, pinto, and red kidney beans. Planting is done in May or early in June following the rainy season and is usually preceded by an irrigation, which germinates the weed seeds that are later destroyed in the process of preparing the field for planting. The next irrigation is applied when the plants are large enough to allow furrowing-out of the rows. A total of 3½ to 4 acre-feet of water is used on the crop, generally in three irrigations.

The beans are usually harvested as dried beans late in fall and put in warehouses for shipment to midwestern or eastern markets when prices are favorable. Yields average 1,500 to 2,000 pounds an acre, but some fields frequently produce 2,500 to 3,000 pounds. This compares favorably with yields in other important bean-growing localities. The beans are of the highest quality and bring good prices. An additional revenue is obtained each year after harvesting from the rental of the fields for sheep pasture. The straw and beans left on the ground by the thresher make excellent feed.

Seed for planting the next season is obtained from parts of various fields that have the best looking plants. About 35 pounds of seed will plant an acre. No fertilizer is used on the crop, and many fields have been planted to beans every year for more than 10 years with no apparent reduction of yields. Occasionally some operators will plant the beans following a winter crop of peas. This practice has met with varying success, but in general the pea crop is only fair and hardly worth the cost of planting and the risk of loss.

A constant danger to beans is from thrips and red spider. Practices of keeping fences, roadways, and ditches free from weeds and dusting the plants with sulfur at the first appearance of the red spider have minimized the losses to a point where they are practically negligible.

GRAIN

Grain is a very important and profitable crop. The grain most extensively grown is barley, 60,072 acres of which were planted in 1939, according to the Federal census of Stanislaus County. Approximately 60 percent of the barley seed is treated with copper carbonate and organic mercury dusts before seeding to control rust and smut. Wheat, grain sorghum, and oats are the next most important grains, in the order named, but the total acreage is small.

With the exception of grain sorghum, which is grown in small irrigated plots, grains are dry-farmed in large tracts on broad alluvial fans and low terraces. A general practice of planting in fall on summer-fallowed land is followed by harvesting late in spring. On the steeper slopes and high terraces, where the soils are less productive, a 3-year rotation is sometimes practiced, consisting of planting and harvesting the first year, harvesting a volunteer crop the second, and pasturing the third. Occasionally large areas of the so-called permanent pasture lands are disked in fall and seeded with the expectation of harvesting a small hay or grain crop, which may or may not yield a profit.

The fields are later pastured to sheep, which clean up the grain left by the combine harvester. The remaining stubble and straw is burned because the rainfall is relatively low and the straw will not decompose by the time tillage and planting operations begin in fall, and so much straw remains undecomposed on the land that it tends to clog tillage implements. Another reason for burning the straw is to conserve the nitrogen in the soil. If the straw, which is high in carbohydrate content, is plowed under the soil bacteria immediately begin to attack this cell-building material and incorporate it into their bodies. An important source of energy for this synthesizing process is the nitrogen contained in the soil, and thus there occurs a temporary nitrate loss until all the straw is decomposed and the bacteria die and return some of the nitrate to the soil.

Yields of grain range from 8 to 15 sacks an acre and grain hay from 1 to 2 tons in normal seasons. The yields are variable, depending largely upon the extent and distribution of the winter rainfall. Most of the grain hay produced is consumed locally; the grain is shipped to State and interstate markets.

ALFALFA

Alfalfa, an extensively grown crop, had an acreage of 67,644 in the county in 1939. Despite this large acreage, it is raised primarily for the extensive dairying enterprises of the west side of the valley, and little if any is sold outside of the county.

Practically all the crop is grown on the flat valley bottoms and is irrigated either by the contour or the border-check method. The general practice is to apply a 6-inch irrigation after each of the 7 or 8 cuttings, which would make an average total of approximately 4 acre-feet of water.

In the main, the yield and quality of alfalfa is not good, primarily because this crop is incidental to the major enterprise of dairying. In many instances the soils are not suited to it, and this together with inconsistent cultivation and irrigation practices makes for generally low yields.

The most serious pest is the alfalfa caterpillar, or yellow butterfly (*Colias philodice eurytheme* Bdv.), which is most active in August and September and completely strips the leaves from one or two cuttings unless controlled. One effective method of control is to make a cutting of the alfalfa just as soon as there has been a large flight of butterflies from the field. This cutting and accompanying raking will destroy most of the eggs deposited and thus materially reduce the number of caterpillars that would hatch.

Some former alfalfa fields are being replanted to Sudan grass and ladino clover, which seem to grow very well on the heavier soils less well adapted to alfalfa. These relatively new crops are high in nutrient value and easy to handle.

FLAX

Raising flaxseed is a very new enterprise in the county. In 1939, 616 acres were used for this crop, mostly in the northern half of the Newman area. Flax is a shallow-rooted crop and can be grown successfully on soils that are heavier and not well adapted to alfalfa or beans. The water requirement is only 1½ to 2 acre-feet for each crop. Yields range from 14 to 22 bushels an acre, depending upon soil and weather conditions. Good prices and a ready market have prevailed in the San Francisco Bay area. The crop is used mainly for oil and many byproducts.

OTHER FIELD CROPS

Birdseed, rice, corn, and cotton are planted in small acreages, aggregating about 1,500 acres each year.

TRUCK CROPS

The total acreage planted to truck and vegetable crops is small, and is confined to the northern half of the area. Much of it, however, is double cropped, and the yields and profits derived have been consistently high.

PEAS

Peas are planted in fall and harvested in spring. Some of the crop is dried and sold locally for seed, but most of the fresh peas are sold to canneries or to local vegetable markets. The yield and quality are only fair compared to other communities, and the uncertainty of market prices tends to discourage too large an investment.

CELERY

Celery has been raised successfully and may become increasingly important. It is essentially a specialty crop and to grow it requires an expenditure of approximately $200 an acre. Yields, however, have been averaging more than 300 half crates an acre.

The general practice is to prepare the seedbed in February and transplant to the fields in June and July. About 5 to 8 tons of manure an acre is applied before field planting, and during the growing period approximately 500 pounds of ammonium sulfate is applied as side dressing in three applications. A total of 8 acre-feet of water in surface irrigation is required before the crop is brought to maturity in December.

LETTUCE

Lettuce is probably the next most important truck crop grown and is frequently rotated with celery. It is planted late in August and harvested in November and December. The fields are usually fertilized with manure before planting and receive several applications of ammonium sulfate during the growing period. Yields are 150 to 175 crates an acre, which will insure a fair profit if market prices are favorable. As other sections of California only a short distance from this area are better suited to lettuce, this crop will probably not be of more than minor importance here.

MISCELLANEOUS TRUCK CROPS

Small acreages varying in size from year to year are planted to melons, onions, and tomatoes. On the average, good yields are obtained, but larger areas elsewhere in California are better suited to these crops. Uncertain market conditions and relatively high cost of production tend to confine the cultivation of these specialty crops to areas where the climate is most favorable.

VINEYARDS

In 1940, 70 farms reported a total of 271,242 grapevines of bearing age in Newman and Patterson Townships. About two-thirds of them are Thompson Seedless and one-third Carignane. There has been a large reduction in vineyard acreage largely because recent investigations have shown that the Sultanina (Thompson Seedless) variety is not especially well suited to the climate; the wide variation between night and day temperatures resulted in reducing the sugar content. This variety is grown for raisins, and production here is in competition with large vineyards farther south in the warmer sections of the valley. The Carignane variety, however, used in wine making, is somewhat better adapted to this area. Yields of 6 to 8 tons an acre are obtained, with a ready market available. The cost of production for this variety will average about $45 an acre.

A special method of control of the Pacific mite (*Tetranychus pacificus* McG.) has been developed. A sticky poison is smeared on the canes behind the base buds and is followed with an oil-emulsion spray. Complete success in control, however, depends upon complete removal of the suckers. These must be removed from each vine, collected, and destroyed.

FRUIT AND NUT CROPS

The census figures for Newman and Patterson Townships showed a total of 3,515 acres in bearing and nonbearing fruit orchards, vineyards, and planted nut trees on April 1, 1940, about 80 percent of it in the northern half of the area. There has been no appreciable increase or decrease in the acreage in orchards during the past few years, because of the relatively high cost of production and uncertain market prices.

APRICOTS

Apricots are the most extensively cultivated orchard crop, the Tilton variety dominating. In a large acreage of bearing trees in the vicinity of Patterson the trees are well adapted to the soil and climate and the

enterprise is profitable when market prices are favorable. Yields average 10 tons an acre, with a production cost of about $190 an acre, shipped to the cannery. A considerable tonnage is dried each year, and drying costs are about $60 an acre additional.

Ordinarily the Tilton variety is not subject to brown rot, but in 1937 and 1938 this disease was rather severe. The most effective control measure is a late winter spraying with bordeaux mixture. Of the pruning methods used the most successful seems to be a tall slim pruning with central wire bracing for protection against the wind.

PEACHES

A total of 87,362 peach trees of bearing age was reported in the 1940 census for Newman and Patterson Townships. A number of varieties are grown but none seem to be more than fairly successful. Neither the soil nor the climate favor this crop particularly well, yet the yield varies from 3 to 20 tons an acre within a small area, which illustrates the effect of soil conditions upon yields.

The Palora, Peak, Sims, Phillips Cling, and Levy are the more common varieties for canning and give an average yield of 8 tons an acre, with a wide production range of 3 to 20 tons. The Lovell and Muir, which yield about 12½ tons an acre, are the freestone varieties used for drying. The J. H. Hale and Late Champion are the principal peaches for shipping and average a net shipping yield of 10 tons an acre.

As in the case of apricots, the usual pruning practice is a tall slim pruning with central wire bracing. This method is a more or less modified Sims method with the hangers cut smaller and the trees kept to a maxium height of 17 feet.

A general and effective orchard practice employed in some places includes an application of ammonium sulfate in fall at the rate of 4 to 8 pounds to the tree, depending upon the soil texture. A cover crop of mustard is planted every year following fall irrigation after the fruit is harvested. This cover crop is plowed under between February 20 and March 15. Pest control varies with prevailing conditions, but in the main standard sprays are used with excellent results. Orchard pests have not been a serious problem in the area.

WALNUTS

Walnuts are probably the next most important tree crop. The groves are small and fairly well scattered. Yield and quality compare favorably with other walnut-growing sections, and a fairly steady market prevails. The average yield is 1,000 to 1,500 pounds an acre.

ALMONDS

About 100 acres is used for almonds, divided about equally between the hard-shell Texas and the soft-shell Nonpareil. Yields of 1,500 to 2,000 pounds an acre have been consistently obtained, with a ready market available. Both the almond and walnut crops have been practically free from serious pest invasions, but other parts of California are a little better suited to these crops climatically. Most of the nut groves are fairly old, and no new plantings have been made within the last 5 years. The total acreage will probably not increase greatly in the future.

DAIRYING

The dairy industry probably contributes more income than any other single enterprise to the inhabitants living in this area (pl. 1, *A*). The valley bottom area between Crows Landing and Newman is believed to have a greater number of cows to the acre than any other dairying community in the United States. On April 1, 1940, 226 farms in Newman Township reported 9,140 cows and heifers kept for milk production, and in Patterson Township 250 farms reported 5,435. The total number of cattle over 3 months old was 13,013 and 7,884 in Newman and Patterson Townships, respectively.

Practically all the feed, which is largely alfalfa, is grown by dairymen on the farms. As a result of a year-round and uniform green-feed supply the milk production per cow is fairly constant. In other areas where pasturing is not possible all the year, milk production fluctuates greatly.

Very little liquid milk is sold to the markets from these dairies. It is produced mainly for butter, cheese, condensed milk, and other by-products. A large milk-condensing plant is at Patterson and a condensing plant and creamery at Newman. Butterfat prices paid by creameries are based on San Francisco market quotations.

This area appears to be well adapted to dairying and will in all probability continue to be a dairy center. A herd of 40 to 50 cows will support a family of 4 or 5 fairly well. The operation of the dairy farm is carried on almost exclusively by Portuguese whose ancestors migrated from the Azores.

GRAZING AND LIVESTOCK

In 1939, 25,242 acres were in pasture in Newman and Patterson Townships. As the boundary of the area does not extend west to the county line, the entire acreage of available pasture is not included, but all of it is grazed by cattle and sheep, which in the 1940 census included 20,897 cattle and calves over 3 months old on April 1 and 5,303 sheep and lambs over 6 months old. The carrying capacity is 10 to 30 acres an animal. More than 50 percent of the pastures will support 1 animal for each 10 acres, but this range is overgrazed.

Practically all the beef cattle are Hereford and raised for California markets. It is possible to finish most of the cattle on the range, but some are shipped to outside markets as feeders. Sheep also are pastured on grain stubble and bean straw in the valley. California markets consume most of the lambs and wool. During wet years grazing is adequate, but in dry years it is difficult to find enough pasture.

Swine is another livestock enterprise of some importance. On April 1, 1940, 40 farms reported 246 swine over 4 months old in the 2 townships. According to the 1940 census 59,503 chickens and 18,038 turkeys were raised in 1939.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field and the recording of their characteristics, particularly in regard to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings are made, and road and railroad cuts and other exposures are studied. Each excavation exposes a series of distinct soil layers, or horizons, termed collectively the soil profile. Each horizon, as well as the underlying parent material, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil and its content of lime and salts are determined by simple tests.[3] The drainage, both internal and external, and other external features, as the relief, or lay of the land, are taken into consideration, and the interrelation of soil and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, with special emphasis on the features that influence the adaptation of the land for the production of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped into classification units, the principal three of which are (1) series, (2) type, and (3) phase. Some areas—that have no true soil—as riverwash and made land are termed (4) miscellaneous land types.

The series is a group of soils having the same genetic horizons, similar in their important characteristics and arrangement in profile, and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage, and other important internal characteristics and the same range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The series are given geographic names taken from localities near which they were first identified. Altamont, Sorrento, and Columbia are names of important soil series in the Newman area.

Within a soil series are one or more types, defined according to the texture of the upper part of the soil. Thus, the class name of this texture, as sand, loamy sand, sandy loam, silt loam, clay loam, silty clay loam, or clay, is added to the series name to give the complete name of the soil type. For example, Sorrento loam and Sorrento clay loam are soil types within the Sorrento series. Except for the texture of the surface soil, these types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the unit to which agronomic data are definitely related. In comparisons of the type and phases of that type, to avoid the repetition of their complete names, the type is sometimes referred to as the normal phase.

A soil phase is a variation within the type, differing from it in some minor feature, generally external, that may be of special practical significance. For example, within the normal range of relief for a soil type some areas may be adapted to the use of machinery and the growth of cultivated crops and others may not. Differences in relief, stoniness, and degree of accelerated erosion may be shown as phases. Even though no important differences may be apparent in the soil itself or in its capability for the growth of native vegetation throughout the

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. Indicator solutions are used to determine the reaction. The presence of lime is detected by the use of a dilute solution of hydrochloric acid.

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range in relief, there may be important differences in respect to the growth of cultivated crops. In such instance the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, some soils having differences in stoniness may be mapped as phases even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types in relation to roads, houses, streams, lakes, section and township lines, and other cultural and natural features of the landscape.

SOILS

The soils of the Newman area fall into six natural groups, based on physiographic position and character of profile, as follows: (1) Hilly and mountainous uplands, (2) recent alluvial fans, (3) young alluvial fans, (4) older alluvial fans, (5) old alluvial terraces, and (6) flood plains and basins.

SOILS OF HILLY AND MOUNTAINOUS UPLANDS

The soils of the hilly and mountainous uplands are in the Gaviota, Altamont, Diablo, Kettleman, Crow Hill, and Vallecitos series and are formed primarily by weathering and development in place. They are used mainly for range pasture, but in places dry-farmed grain is planted, usually in rotation with summer fallowing. A pasture area is occasionally plowed, harrowed lightly, and planted, and if the season is favorable will produce a profitable yield. If the season is unfavorable, the increase in pasture from the grain crop at least partly pays for the cost of preparing the field. All these soils produce some grain, except the Kettleman and the Vallecitos, which have steep relief. Most of the grain areas are in the lower hills between Little Salado and Garzas Creeks. All other soils of this group are used as range pasture—in the northern and central parts for sheep and in the southwestern for cattle.

SOILS OF RECENT ALLUVIAL FANS

Most of the soils of the recent alluvial fans occur on broad alluvial fans with very smooth but gently sloping relief. They have recently accumulated, have undeveloped or feebly developed soil profiles, and are the most favorable for agriculture in the area. This group includes the Mocho and the Sorrento series (pl. 1, *B*). The Sorrento are by far the most extensive. These rich alluvial soils are suitable for a wide variety of field and orchard crops under irrigation.

SOILS OF YOUNG ALLUVIAL FANS

The soils of the young alluvial fans include the Dublin and Zamora series, both of which are represented by single soil types of heavy clay texture and blocky "adobe" structure. Of these the Zamora exhibits a little more strongly developed profile, indicating a little older condition and more advanced stage in soil development than the soils of the recent alluvial fans, and somewhat younger and less advanced stage than most of those of the older alluvial fans. The Zamora is a strong

fertile soil but lies above sources of water supply for irrigation and is used mainly for dry-farmed grains and range pasture. The Dublin occurs in small bodies on minor alluvial fans at the edge of the valley or in small valleys between the hills where irrigation water is not available. It is used mainly for dry-farmed grain, the yield of which is usually more dependent upon the season than upon the individual soil type.

SOILS OF OLDER ALLUVIAL FANS

The soils of the older alluvial fans occupy the alluvial fan areas in positions similar to those of the recent alluvial fans, but they have somewhat more compact and less open and freely permeable subsoils. This group includes the Esparto, Pleasanton, Ambrose, Rincon, and Herdlyn series.

Most of the Esparto soils occur close to the hills, above available water for irrigation, and are used mainly for dry-farmed grain or range pasture. They have the least profile development of any of the soils in the group, and if water were available they should be almost as productive as the Sorrento and Mocho of the recent alluvial fans. All other soils of the group occur partly at least in irrigated areas most of which are fairly productive, but orchards and vineyards do not do so well as on the recent soils. Beans (pl. 2, *A*), alfalfa, and grain grow fairly well and flax is becoming more and more important, especially in the northern part of the area. Flax is planted in winter or early in spring and usually can be matured with one irrigation. It seems to yield almost as well on some of the more strongly developed soils as on the recent alluvials. The Herdlyn has the most strongly developed subsoil of the group and is better suited to grain than to any other crop. Alfalfa is planted in a few small areas, but the yields are low and the stand lasts only a few years.

SOILS OF OLD ALLUVIAL TERRACES

The soils of the old alluvial terraces are members of the Denverton, Positas, and Ohmer series and are used principally as pasture for sheep, although dry-farmed grain does very well on the lower terraces of the Denverton. Grain is occasionally planted on the Ohmer and Positas soils, but grain cannot be farmed profitably in the common rotation with summer fallow under average seasonal rainfall. In favorable seasons profitable crops can be raised on both these soils. All the soils of this group produce good pasture.

SOILS OF FLOOD PLAINS AND BASINS

The soils of the flood plains and basins are members of the Orestimba, Columbia, Dinuba, Sacramento, and Merced series. The Orestimba soils occupy low flat or very gently sloping areas marginal to the older alluvial fans. They have a high water table and some alkali[4] accumulations. Alfalfa grows fairly well, but the soils are better suited to grain and pasture for dairy stock. The other soils of this group consist of accumulated alluvial materials transported and deposited by flood waters of the San Joaquin River. The sediments are

[4] The term alkali is used in this report in its popular or agricultural sense to indicate an excessive accumulation of soluble mineral salts that may be of either neutral or alkaline chemical reaction.

derived from a wide range of geologic materials. The soils occupy flood-plain and shallow basinlike backwater areas subject to overflow at times of high water where not protected by levees or dikes. If protected from overflow and improved by drainage they are productive and can be utilized for a wide range of crops.

DESCRIPTIONS OF SOIL UNITS

The 23 soil series in this area are represented by 38 soil types and 38 phases.[5] There are also 2 miscellaneous land types—made land and riverwash—which are not properly soils and have no agricultural significance but are of some importance in commercial use and in connection with grazing and stock raising. In the following pages the soils are described in detail; their location and distribution are shown on the accompanying soil map; and their area and proportionate extent are given in table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in the Newman area, Calif.*

Soil type	Acres	Percent
Altamont clay (adobe)	3,456	1 8
Eroded phase	1,920	1 0
Eroded steep phase	1,152	6
Rolling phase	192	.1
Steep phase	1,408	.8
Altamont clay loam	704	4
Eroded phase	1,472	8
Eroded steep phase	2,432	1 3
Rolling phase	256	.1
Steep phase	2,624	1 4
Ambrose clay (adobe)	5,248	2 8
Shallow phase (over Fresno soil material)	512	.3
Ambrose clay loam	512	3
Columbia fine sandy loam	320	2
Columbia silty clay loam	128	1
Columbia soils, undifferentiated	4,032	2 2
Crow Hill clay	128	1
Crow Hill clay loam	128	.1
Eroded phase	192	.1
Rock-outcrop phase	64	(1)
Rolling phase	192	1
Denverton clay (adobe)	6,144	3 3
Eroded hilly phase	256	1
Hilly phase	1,152	6
Rolling phase	2,176	1 2
Denverton gravelly clay [2]		
Hilly phase	448	2
Rolling phase	832	.4
Steep phase	1,536	8
Diablo clay (adobe)	448	2
Rolling phase	704	.4
Dinuba fine sand	256	1
Dublin clay (adobe)	256	.1
Esparto gravelly sandy loam	1,664	9
Gaviota fine sandy loam	3,136	1 7
Eroded phase	1,600	9
Eroded rock-outcrop phase	4,608	2 4
Eroded steep phase	1,280	7
Rock-outcrop phase	5,888	3 1
Rolling phase	1,468	8
Steep phase	512	3
Herdlyn loam	192	0 1
Kettleman clay loam	1,792	1 0
Eroded phase	2,368	1 3
Eroded steep phase	1,664	9
Rock-outcrop phase	448	.2
Steep phase	576	3
Kettleman fine sandy loam	448	2
Eroded phase	768	4
Eroded steep phase	1,216	6
Rock-outcrop phase	2,816	1 5
Rolling phase	512	.3
Made land	64	(1)
Merced clay loam	1,216	.6
Mocho clay loam	2,752	1 5
Mocho fine sandy loam	3,648	1 9
Mocho gravelly loamy sand	576	.3
Ohmer gravelly loam	320	.2
Hilly phase	960	5
Undulating phase	704	4
Orestimba clay loam	3,200	1 7
Orestimba loam	256	1
Pleasanton gravelly clay loam	3,648	1 9
Pleasanton gravelly sandy loam	1,600	9
Positas gravelly clay loam	576	3
Hilly phase	256	1
Rolling phase	192	1
Undulating phase	384	2
Rincon clay	18,176	9.7
Rincon clay loam	2,752	1 5
Riverwash	768	4
Sacramento silty clay	3,904	2 1
Sorrento clay loam	25,664	13 7
Sorrento fine sandy loam	9,088	4 9
Sorrento gravelly loam	2,880	1 5
Sorrento gravelly sandy loam	2,944	1 6
Sorrento loam	25,152	13 4
Vallecitos stony clay loam	1,472	8
Zamora clay (adobe)	192	.1
Total	187,520	100 0

[1] Less than 0 1 percent.

[2] Typical soil not mapped.

Altamont clay (adobe).—The surface soil is dull brown or dull grayish-brown noncalcareous heavy clay of high colloidal content.

[5] When a soil type is subdivided into phases, that part of the type that bears no phase name will be referred to as the normal phase of the type.

When dry it shrinks and large cracks develop that extend deep into the subsoil; when wet it is extremely sticky and plastic. Later smaller cracks form and the surface soil is broken down to a mass of small angular fragments or aggregates. Numerous grass and other roots penetrate this layer. Some shale fragments occur and occasionally in the lower part some are coated with lime.

At a depth of 8 to 24 inches the brown to grayish-brown calcareous heavy clay subsoil has a somewhat lighter shade than the surface layer and is more compact. The surface cracks extending into this layer give it a somewhat irregular prismatic structure, but the aggregates break into irregular-shaped units that are considerably larger than those in the surface soil. Some sloughing-off of the darker colored surface material into the cracks gives parts of this layer a somewhat mottled appearance. Some of the aggregates and root and insect channels are stained with dark-colored colloids. Roots are fairly well distributed in the subsoil but they decrease in number, with depth, while the rock fragments increase and the color becomes lighter. A little segregated lime and occasionally some crystalline gypsum are in the lower part of this layer.

Parent bedrock occurs at a depth of 2 to 4 feet. The upper part is soft shattered shale in which soil material and some plant roots occur in the cracks. Calcium carbonate coats the rocks and some gypsum crystals may occur. In most places the deeper unweathered shale bedrock is noncalcareous.

This soil is of hilly to mountainous relief, the western slopes being steeper than the eastern. It is closely associated with Altamont clay loam and with types of the Kettleman and Diablo series but differs from them in color. Because of the adobe structure, water enters the soil through cracks that persist until the soil is saturated and runoff is slow, so that despite the fairly steep slopes erosion is usually slight.

The soil is normally covered with grass and associated plants and is used almost entirely for range pasture. It supports a heavier grass cover than any other type of the residual foothill and mountain soils, except the Diablo clay (adobe), which is of about equal grazing value. The forage on this and the Diablo soil is a little more palatable for sheep and is usually grazed first. A total of 3,456 acres is mapped.

Altamont clay (adobe), eroded phase.—This phase, with slopes of 15 to 40 percent, represents areas of this soil type in which erosion is moderately severe to severe.

The surface soil is dull-brown or dull grayish-brown noncalcareous clay with an adobe structure. The subsoil is light-brown to brown calcareous compact clay, with some segregated lime and in places some gypsum in the lower part. The upper 2 to 4 feet of the shale bedrock is crumbled, the rocks are coated with lime, and some soil material has lodged in the cracks. The shale becomes increasingly massive with depth.

As the adobe structure makes the soil resistant to erosion, only small areas of the eroded phase occur. These occur in localized areas, particularly along fault lines or where drainage waters from higher slopes converge. Most of the eroded areas are badly gullied, especially along fault lines. Overgrazing for too long periods also causes serious erosion. A total of 1,920 acres is mapped.

Altamont clay (adobe), eroded steep phase.—This eroded steep phase represents areas of this soil type where the slope is in excess of 40 percent and erosion is moderately severe to severe.

The surface soil is dull-brown or dull grayish-brown noncalcareous clay with an adobe structure. The subsoil is light-brown or brown calcareous clay of blocky structure. There is segregated lime and often some crystalline gypsum in the lower part of the subsoil and in the crumbled soft upper part of the bedrock. The bedrock is stratified shale, usually noncalcareous.

Erosion is usually moderately severe sheet erosion with occasional deep gullies cut into the hard bedrock. There are also many areas where pot holes occur. The sheet erosion and occasional gullies are usually caused by overgrazing, and the pot-hole areas are enlarged by overgrazing but usually occur along fault lines where the bedrock has been shattered to considerable depth by faulting.

Areas of this sort are small and inextensive. They should be carefully grazed to permit stabilization of gullies and sheet erosion. A total of 1,152 acres is mapped.

Altamont clay (adobe), rolling phase.—This rolling phase represents the less steep areas of the soil type. The profile may have slightly more compact subsoil than is characteristic of this series.

The surface soil is dull-brown or dull grayish-brown neutral or slightly acid clay with distinct adobe structure. The subsoil is light-brown moderately compact clay with a blocky structure and some colloidal stains coating the soil aggregates. The material is calcareous, with some segregated lime in the lower part of the layer, with which gypsum crystals may be associated. The parent material is weathered somewhat deeper than is characteristic of other types and phases in this series and has considerable segregated lime and gypsum interspersed with the crumbling shale bedrock. The unweathered bedrock of stratified shale is noncalcareous.

This soil occurs in small bodies, mostly along Orestimba and Oso Creeks. Erosion is generally very slight, and this soil can be used for dry-farmed grain. The natural grass cover is fairly heavy and the forage appears very palatable. A total of only 192 acres is mapped.

Altamont clay (adobe), steep phase.—The steep phase represents areas of the soil type where the slopes are in excess of 40 percent, but they are smooth and the ridges and hilltops are rounded. In general the profile is like that of the normal phase, but there is more variability in depth to bedrock and the subsoil is likely to be a little less compact.

The surface soil is dull-brown or dull grayish-brown noncalcareous clay with an adobe structure that is somewhat compact, and the aggregates are thinly coated with colloidal stains. The subsoil is brown to light-brown calcareous clay with a blocky structure. Segregated lime and occasionally some crystalline gypsum occur in the lower part. The upper part of the shale bedrock is weathered and crumbled and contains some segregated lime and occasionally some gypsum. The lower bedrock of stratified shale is normally noncalcareous.

Sheet erosion is moderate with occasional gullies. The natural grass cover, together with a favorable structure, makes this soil moderately resistant to erosion. Because of the steep slopes it should be

used only for grazing. This soil is mapped along the western part of the area between Orestimba and Puerto Creeks in aggregate of 1,408 acres.

Altamont clay loam.—The surface soil is dull-brown or dull grayish-brown noncalcareous clay loam of soft cloddy character when disturbed and contains many roots with a few fragments of fine-grained sandstone or shale. In the lower part some of these rock fragments may be coated with lime. There is a wide variation in thickness of the surface soil, which ranges from a few inches to almost 2 feet, with an average of 10 to 12 inches.

The subsoil consists of brown calcareous heavy clay loam or clay slightly more compact than the surface soil. There is some colloidal staining and often a little mycelial lime in the lower part. A number of roots are present, although they are not so numerous as in the surface soil. The rock fragments become more numerous with depth, and most of them are coated with lime. A few gypsum crystals sometimes occur in the lower part.

Bedrock occurs at depths of 1 to 4 feet, with an average of about 2 feet. The upper part is soft and somewhat cracked and crumbled, with some soil material and plant roots in the cracks. Rock surfaces are coated with lime, and gypsum crystals are occasionally found in the cracks. Unweathered bedrock is usually noncalcareous.

This soil is used almost entirely as range pasture for sheep to which it is well suited. The grass cover is fairly heavy, although it is generally overgrazed.

Erosion is not so severe on this soil as on Gaviota fine sandy loam but more severe than on Altamont clay (adobe). In general, the western slopes are a little steeper and the soil is a little more shallow, vegetation is somewhat more sparse, and erosion is more severe.

This soil occurs in the hilly areas and is closely associated with other Altamont types and with soils of the Kettleman series. A total of 704 acres is mapped.

Altamont clay loam, eroded phase.—This phase is usually more shallow than the normal phase and occurs more frequently on western slopes with gradients of 15 to 40 percent. Moderately severe sheet erosion with occasional gullies is the most common type of erosion, but there are small localized areas of severe sheet erosion with numerous gullies.

The surface soil is dull-brown or dull grayish-brown clay loam, and the subsoil is brown to light-brown slightly compact calcareous clay loam or clay, with some segregated lime, usually in the lower part. The upper part of the bedrock is shattered and crumbled fine-grained sandstone or shale, with lime coating the surfaces of the loose rocks. The lower part is more massive and is usually noncalcareous.

Most of this soil is used as grazing land for sheep and is badly overgrazed. Controlled grazing, particularly by delaying the time of turning in sheep in winter, should materially aid in reducing erosion. Gullying in faulted areas could be materially helped by mechanical methods of control, but such methods are difficult where the bedrock is shattered. Controlled grazing should materially reduce erosion even along faults.

This soil occurs mostly along the western slopes of ridges from Orestimba Creek northward. A total of 1,472 acres is mapped.

Altamont clay loam, eroded steep phase.—This phase represents areas of the soil type where the slope is in excess of 40 percent and erosion is moderately severe to severe. The soil profile is variable in depth and degree of subsoil development.

The surface soil is dull brown to dull grayish-brown noncalcareous clay loam that breaks into soft aggregates when disturbed. The subsoil is brown to light-brown calcareous clay loam or clay with segregated lime in the lower part. The upper part of the bedrock is weathered and includes segregated lime and soil material in the cracks. The lower bedrock is massive sandstone or shale.

Severe gullies and pot holes have been developed in small localized areas, often caused by severe overgrazing; others occur along fault lines where the bedrock has been shattered. Erosion is increased by overgrazing. Areas pastured to sheep are more severely overgrazed than those pastured to cattle. After erosion starts it becomes increasingly serious, yet in areas where grazing has been reduced, the vegetative cover soon gains a better foothold and erosion becomes less active.

This soil occurs in the western part of the area, mostly from Puerto Creek southward. A total of 2,432 acres is mapped.

Altamont clay loam, rolling phase.—The profile of this rolling phase is similar to that of the normal phase but the slopes are complex and more gentle, less than 15 percent.

The surface soil is dull-brown or dull grayish-brown neutral or slightly acid clay loam breaking into soft cloddy aggregates when disturbed. The subsoil is brown to light-brown heavy clay loam or clay with moderate compaction. The aggregates are irregular in shape and coated with colloidal stains. This layer is calcareous with some segregated lime lining the root holes and coating the soil aggregates. The upper foot or two of the bedrock is soft and crumbled, with lime coating some of the rock surfaces, and there is some soil material in the cracks.

This soil is used mainly for grazing sheep. It is inextensive and limited to only a few scattered bodies, although the soil would be suitable for dry-farmed grain in favorable seasons. A total of 256 acres is mapped.

Altamont clay loam, steep phase.—This phase represents areas of the normal phase where the slopes are in excess of 40 percent. The variation in depth or thickness of soil material is greater than where the slopes are not so steep, and in many places subsoil development is less pronounced.

The surface soil is dull-brown or dull grayish-brown noncalcareous clay loam, of soft cloddy character when disturbed. The subsoil is brown to light-brown calcareous clay loam or clay and usually slightly more compact. Segregated lime usually occurs in the lower part of the subsoil and in the crumbled upper part of the parent bedrock. The deeper parent material is light-brown to gray sandstone or shale bedrock.

Because of the steep slopes this soil can be used only for range pasture in winter and spring. The native cover is grass, with a few shrubs on very shallow areas. Overgrazing is the most serious problem as it increases erosion, which at present is mostly moderate sheet erosion with occasional gullies.

This soil occurs in scattered bodies along the western side of the area in an aggregate area of 2,624 acres.

Ambrose clay (adobe).—To an average depth of about 12 inches the surface soil is noncalcareous dark somewhat gray clay containing slight to moderate quantities of organic matter. During dry periods in summer a pronounced adobe structure is developed forming large blocks separated by deep vertical cracks. These large blocks become weakened by smaller secondary cracks and are reduced to small hard fragments or aggregates. When wet the soil is very plastic and difficult to handle. Roots penetrate the surface layer easily, but internal drainage is relatively slow. No injurious concentrations of salts are in the soil.

The upper subsoil layer is dark grayish brown of similar texture and usually contains some disseminated lime. The surface cracks extend into this layer and provide channels that facilitate root and water penetration. This layer is dense and some colloidal stains are on the aggregates. When wet it is very tough and sticky, and when dry large hard blocks are formed when disturbed. To depths of 4 or 5 feet, the lower subsoil layer is grayish brown and dense, with considerable segregated lime carbonate in both a mycelial and soft nodular form. Dark colloidal stainings also are present. Some of the surface cracks extend into this layer and the darker surface soil that has fallen into the cracks gives it a streaked or mottled appearance.

The deeper soil material is generally light brown containing large quantities of disseminated lime, and often is lighter textured than the soil above and more friable. There is no colloidal staining and very few roots and insect burrowings are present at this depth.

Some of this soil is irrigated and planted to beans or peas, but only fair yields are obtained. Other areas are dry-farmed to grain for which this heavy-textured soil is well adapted. The surface is nearly level or very gently sloping.

This is the most extensive soil of the Ambrose series. A total area of 5,248 acres is mapped. Several large bodies are west of Patterson and Westley.

Ambrose clay (adobe), shallow phase (over Fresno soil material).—The upper 30 to 40 inches has essentially the same characteristics as the normal phase. The surface soil is usually dark grayish-brown clay. The adobe structure is always apparent when in dry condition but is more pronounced in some areas than in others. This layer does not contain lime and often has a considerable quantity of organic matter. The soil is dense and is very sticky when wet and forms large hard blocks and smaller aggregates when dry. Both internal and external drainage are retarded, and slight to moderate quantities of alkali salts occur throughout the profile.

To a depth of 30 to 40 inches the upper subsoil is dull-brown mildly calcareous compact heavy dense clay, with a tendency when dry toward the development of small hard cubical aggregates. It is streaked in the lower part with darker material of surface soil that has fallen into the cracks. Roots are not so numerous in this layer as in the surface soil. This layer rests abruptly on a substratum apparently representing older buried material of the Fresno soils.

This material is light gray and contains large quantities of segregated lime and fairly large gypsum crystals. An appreciable quantity

of iron and organic staining of the aggregates gives the material a mottled appearance, especially where the water table has been consistently high. At a depth of about 50 inches or more, some lenses of cemented hardpan occur, some of which are very hard, and large lime carbonate nodules or fragments of the hardpan are frequently encountered. The usual lower subsoil of the Ambrose soils is replaced by material similar to that of the Fresno.

As this is not a good agricultural soil, it is used mainly for pasture. Its high water table precludes use for anything but shallow-rooted crops, and in a dairying area such as this it is better used for pasture than for any cultivated crop. A total of 512 acres is mapped. Although not extensive in this area, several fairly large nearly level bodies are located east of Patterson close to the rim of the basin soils.

Ambrose clay loam.—The 10- to 15-inch surface soil is dark brownish gray, noncalcareous, and contains small to moderate quantities of organic matter. When disturbed the soil breaks into rather large irregular clods that are easily crushed. It is readily penetrated by roots and water and is retentive of moisture. Plow soles are readily formed, and there is some tendency toward puddling if the soil is worked too wet.

The upper subsoil layer is generally dark grayish brown, intermittently calcareous, and somewhat heavier textured than the surface soil. It is moderately compact and there is considerable dark colloidal staining on the face of the soil aggregates. In some places there is a slight suggestion of cubical structure when thoroughly dry. Root and water penetration is somewhat retarded by the subsoil, which though tough and plastic when wet is fairly well drained and free from alkali. The lower subsoil is lighter colored than the layer above and contains considerable segregated lime in both mycelial and soft nodular forms. This horizon is also moderately dense and compact and has no definite structure in place. The lime carbonate content tends to modify the density and facilitate root and water penetration.

Below a depth of 4 or 5 feet the material is light brown, of medium heavy texture, open, and friable. It contains large quantities of disseminated lime, but is without colloidal staining, and has only a few root and insect holes. The moisture content is usually low at this depth, mainly because the low rainfall is absorbed by the material above.

This soil is dry-farmed to grain and produces good yields when winter rains are favorable. Probably this is as good a crop as any for this soil because the tough subsoil is less desirable for deep-rooted crops. The surface is nearly level or very gently sloping. A total of 512 acres is mapped. A few representative bodies are approximately 4 miles southwest of Newman.

Columbia fine sandy loam.—The surface soil is light-brown noncalcareous loose friable fine sandy loam of little or no structural development. The soil contains considerable mica and is mottled with rusty-brown iron stains. It is somewhat stratified but the differences in texture are minor.

The subsoil, at depths of 8 to 24 inches, consists of light-brown noncalcareous stratified sediments usually similar in general texture to the surface soil. The mottling is usually more pronounced and

becomes duller with depth, but the stratified material includes some loamy sand in which the mottlings are not so numerous as in the fine sandy loam material. This subsoil extends to considerable depths in most places, but there are a few bodies underlain by heavier textured dark-colored material similar to that of the Sacramento series. This material occurs only infrequently and at a depth of 3½ feet or more.

Occupying a total of 320 acres this soil occurs along the flood plain of the San Joaquin River and is derived from material having its source mainly in granitic rocks but with a little material from sedimentary rocks. It occupies the low flat river flood plain and under natural conditions is subject to overflow. Most of it is now protected by levees and drained by open ditches.

This soil is easily tilled and is suitable to a wide variety of field and truck crops, but is used in this area mainly for grain and alfalfa. Because of the high water table, alfalfa stands last only 3 or 4 years, but the yields are good when in full production.

Columbia silty clay loam.—The surface soil is light-brown to light yellowish-brown noncalcareous friable silty clay loam, with some clay loam or silt loam variations. It is mottled with rust-brown iron stains and is somewhat stratified, often with very thin laminated layers, indicating successive flood periods of light deposition. This soil is friable, forming a fine granular structure under cultivation, and it seldom puddles even by tillage at unfavorable high moisture content.

Occurring at depths of 10 to 20 inches the subsoil consists of light-brown or light grayish-brown noncalcareous stratified medium- to medium-heavy textured micaceous materials highly mottled with iron stains. The mottlings are more numerous than in the surface soil and become duller with depth. Most bodies of this soil are underlain at depths of 2 to 5 feet by dark-colored material very much like the Sacramento soils.

The soil occupies low flat flood plain areas of the San Joaquin River north of Grayson that are subject to occasional overflow, although they have been partly protected by levees. The total area mapped is 128 acres and is used almost exclusively for grain, although it is suitable for a wide variety of truck and field crops. The high water table does not allow successful use for orchard and vineyard crops, and alfalfa stands seldom last longer than 3 or 4 years, although the yields are good while in full production.

Columbia soils, undifferentiated.—These undifferentiated areas are of extremely variable texture, ranging from fine sand to silty clay loam, but consisting mainly of medium and light-textured materials. Most of these are light-brown or light yellowish-brown, stratified, and mottled with iron stains, which are duller and more pronounced with increase in depth.

These soils occur near the San Joaquin River and are subject to overflow almost annually. Sandy streaks and ridges formed one season may be removed the next. Such a complex association makes it impracticable to separate the various textured members of these soils in mapping. In profile they are loose, lightly stratified, and strongly mottled with iron stains.

A total of 4,032 acres is mapped along the San Joaquin River, but not in very large bodies. They are used for pasture when the river is not in flood and make satisfactory summer pasture because the period of overflow usually occurs early in June and the grasses remain green through July and August, when grasses on higher areas have dried.

The native cover includes patches of grasses with shrubs, vines, brush, and cottonwood and other trees along the river's edge. A number of sloughways and low sand ridges give the surface an uneven relief. Without protection from floods, these soils cannot be farmed.

One small area about 1 mile northeast of Grayson is of somewhat darker color and higher content of organic matter than the others. It is overflowed only in seasons of unusually high water and is used for pasture and grain.

Crow Hill clay.—The 6- to 12-inch surface soil is dull grayish-brown noncalcareous friable clay. When disturbed it breaks into irregular-shaped clods that are reduced with only slight pressure to a granular condition. Many grass roots are present throughout this layer, but the quantity of organic matter is low. Plowed areas bleach out very rapidly, and the color is somewhat lighter than the unplowed. Reaction is very slightly acid.

The subsoil is dull but somewhat lighter grayish brown than the surface soil. It is mildly compact cloddy noncalcareous clay or silty clay and breaks into irregular-shaped clods that are more firm than those in the surface soil. Angular rock fragments throughout this material increase, and the quantity of grass roots decrease, with increase in depth. The reaction is about the same as that of the surface soil.

Bedrock, consisting of light-gray neutral to mildly acid diatomaceous shale occurs at a depth of 12 to 26 inches. The upper part is shattered and some soil and grass roots extend downward into the cracks.

The slopes are more gentle on this soil than on Crow Hill clay loam, and erosion is not so severe. Gully erosion is very slight, and most of this soil is a little deeper and slightly darker in color.

The natural vegetation is grass, and the soil is used mainly for range pasture. A few areas are cultivated to dry-farmed grain, but these are not planted regularly and only as speculative ventures based on the possibility of a favorable season. Such ventures are seldom successful, but the increased pasture at least partly pays for the cost of seeding. Only 128 acres is mapped.

Crow Hill clay loam.—The surface soil is dull brownish-gray to light brownish-gray noncalcareous clay loam of low volume weight and when disturbed breaks into soft cloddy aggregates. Many very fine pores, small root holes, and grass roots permeate this layer, but there are very few insect holes. Some angular shale fragments occur in the surface soil and increase in number with depth. The soil is slightly or moderately acid.

At a depth of 6 to 15 inches the subsoil is light brownish gray, somewhat more compact, and of blocky structure. Soil aggregates are more firm than in the surface soil but are easily crushed. The texture is similar to that of the surface soil or slightly heavier, approaching a heavy silty clay loam or silty clay. Very little colloidal staining is

observed in this layer. The grass roots are not very numerous, and the quantity of rock fragments increases with depth. The reaction is similar to that of the surface soil.

The bedrock is a light-gray or white diatomaceous shale, the upper part shattered and cracked, and containing some soil material and plant roots in the cracks. It is usually acid, but some of it is nearly neutral. The soil material is shallow, with bedrock seldom deeper than 10 or 20 inches, except where changes in slope have permitted the accumulation of some material by deposition.

The slopes seldom exceed 40 percent. The ridge tops are well rounded. Erosion, especially sheet erosion, is fairly severe. The vegetation is not sufficiently dense to give ample protection against erosion, and as overgrazing causes the upsetting of the rather delicate balance, severe sheet erosion follows. Gullies are not very frequent. Eroded areas appear much lighter colored than Crow Hill clay, and this appearance is intensified by a concentration on the surface of light-colored rock fragments that are not so easily washed away as the soil material.

The native vegetation is grass but it does not form a very heavy cover. This soil is used mainly for range pasture by both sheep and cattle. Some of the lower slopes are used occasionally for dry-farmed grain. These ventures seldom pay, but some increased pasture partly repays the cost of preparing the field and sowing the grain. This soil, occupying a total of only 128 acres, occurs on narrow ridges in the southwestern part of the area south of Crow Creek. The larger areas are between Crow and Orestimba Creeks.

A few variations, mostly textural, are included with this soil, some containing considerable silty material, others a little gravel. These variations, however, are minor and areas of such inclusions are very small.

Crow Hill clay loam, eroded phase.—The surface soil is light-gray strongly acid clay loam of low volume weight. The subsoil is light-gray acid clay loam or clay. Although porous, it is somewhat more dense than the surface soil. The parent material is almost white diatomaceous shale, with an acid reaction.

This phase represents areas of the soil type with slopes of 15 to 40 percent in which erosion is excessive. They have a particularly light color, since the somewhat darker surface soil has been removed. The vegetation is not heavy and does not offer very good protection against sheet erosion and gullying. Most of the 192 acres mapped is adjacent to the old valley terraces between Crow and Orestimba Creek.

Crow Hill clay loam, rock-outcrop phase.—This phase differs from the normal phase mainly in the quantity of outcrop bedrock, which comprises at least 25 percent of the area; and in more shallow depth, which seldom exceeds 10 inches.

The surface soil is often lighter in color than the normal phase and usually there is little distinction between it and the subsoil. Many light-colored rock fragments occur throughout the profile, and in eroded areas they accumulate at the surface. The parent bedrock is soft diatomaceous earth, somewhat shattered and crumbled where exposed at the surface. A few plants are found in some of the cracks, otherwise the exposed bedrock is bare.

The grass on the rest of these areas is sparse, and overgrazing has reduced its quality and quantity. The resulting erosion further denudes these areas and they produce very poor pasture. Only 64 acres is mapped.

Crow Hill clay loam, rolling phase.—This phase consists of areas of the soil type having more rolling relief and slopes of less than 15 percent. The surface soil is dull-gray friable moderately acid clay loam of a low volume weight. The dull color is due to accumulated organic matter. The subsoil is light-gray acid clay loam or clay, somewhat more compact but containing numerous very fine pores. The parent material, consisting of almost white, light weight, acid diatomaceous shale, is encountered abruptly.

The grass cover is fairly dense and, because of the gentle slope, erosion is slight. The land is used mostly for range pasture for sheep and cattle, but occasionally some is plowed and planted to dry-farmed grain. Grain yields are usually low, but they are dependent more upon quantity and distribution of rain than on the soil. A total of 192 acres borders the valley between Crow and Orestimba Creeks.

Denverton clay (adobe).—The 6- to 12-inch surface soil is brown, grayish-brown, or rich-brown noncalcareous clay with an extremely well-developed friable adobe structure. When dry the shrinkage cracks are large and contain some surface material that has fallen into them. Many grass roots are uniformly distributed throughout this layer. The adobe blocks develop many secondary cracks during the dry summer, breaking down to small roughly cubical or irregular aggregates that are only moderately firm and easily reduced to a granular condition when in a favorable, moist condition. This soil has excellent physical properties and is easily maintained in favorable condition.

To a depth of 24 to 36 inches the upper subsoil is similar in color to the surface soil. It is a heavy clay with shrinkage cracks extending through it to the lower subsoil, giving this material a somewhat prismatic structure. This is of blocky structure with some colloidal staining on the soil aggregates, which are much larger than those in the layer above. Most of the root and insect holes are lined with a colloidal coating. Free lime occurs throughout this layer, often with some visible lime in a mycelial pattern in the lower part. The lower subsoil to a depth of 40 to 60 inches is rich-brown or light reddish-brown highly calcareous clay. Many colloidal stains are on the soil aggregates, which are irregular in shape and fairly large. These are compact and broken down with some difficulty. Lime is accumulated in seams and large soft blotches. This lime, together with some darker material that has fallen down the adobe cracks, gives the layer a somewhat mottled appearance. There are a few dark manganese stains, especially in the lower part. The number of roots decreases rapidly with depth, and fewer insect holes are present than in the layer above.

The underlying parent material consists of rather soft calcareous stratified layers, mostly of heavy-textured material but sometimes containing considerable gravel. Some segregated lime occurs and in places partly cements the gravel.

This soil, with a total of 6,144 acres, occupies the smoother parts of terraces at the base of the uplands in the western part of the area.

A, Dairy herd in alfalfa pasture. Dairying is one of the more important industries in the Newman area. *B*, Landscape in western part of the area, which is mainly unirrigated and is used for grazing sheep and range cattle: Riverwash on bottom land of Orestimba Creek in foreground; Sorrento soils on stream terrace in center; Kettleman soils on hills in distance.

A, Baby lima beans growing on Rincon soils. This important crop of the Newman area is grown also on Mocho and Sorrento soils. *B*, Harvesting dry-farmed barley by combine on Esparto gravelly sandy loam. Growing dry-farmed grain, mainly barley, is an important activity on unirrigated lands, and yields are good in favorable seasons.

These terraces have broad, flat, or gently rolling tops and sloping sides. The general relief is rolling, and for the most part the side slopes are not very steep. Erosion is slight and runoff, slow. Much of the rain water is absorbed by this soil with its deep surface cracks, which persist well into the rainy season, and by its high water-holding capacity.

The native vegetation is grass, which grows luxuriantly during the rainy season. Much of this soil is used for range pasture. Where farmed it is used for dry-farmed grain in rotation with summer fallow. No irrigation water is available, and the rolling relief would make irrigation difficult. Yields of grain are almost as good as on the flatter valley soils.

A few small areas are included in which the texture of the surface soil is a little lighter than typical and in which the adobe structure is less pronounced. Some gravel may occur in small localized areas, both on the surface and throughout the profile. The gravel is hard, rounded, and mostly of quartzite rock.

Denverton clay (adobe), eroded hilly phase.—This phase represents areas of the soil type occupying the terrace edges or escarpments where the slopes are in excess of 20 percent and erosion is moderately severe to severe. Profiles along the terrace edges are extremely variable and not so well developed as on the flatter parts of the terraces.

The surface soil is brown, grayish-brown, or rich-brown noncalcareous clay of adobe structure but with friable consistence when in favorable moisture condition. This may rest on a lighter colored subsoil of calcareous clay or on stratified parent material that also is calcareous and often gravelly. In places considerable surface material may have accumulated at the base of the slopes from the steeper slopes above.

The soil is subjected to both sheet and gully erosion, the gullies often cutting deep into the parent material more rapidly than through the soil mantle. The 256 acres mapped occurs mostly in narrow bodies bordering larger areas of flatter Denverton soils. It is used entirely for range pasture.

Denverton clay (adobe), hilly phase.—This hilly phase represents areas of the soil type occurring mostly along the edges of terraces with slopes in excess of 20 percent. The profiles are variable and are not so distinct as on the flatter terrace tops.

The surface soil is brown, grayish-brown, or rich-brown noncalcareous clay of friable adobelike structure. The subsoil is calcareous clay with great variability in structure. In some places the deeper stratified calcareous parent material is encountered at a shallow depth, and in others the surface soil has been built up by material sloughed or washed down from higher slopes.

This phase is used only for range pasture. Erosion is not severe, but most of the bodies of the normal phase in similar locations have considerable erosion and are recognized as an eroded hilly phase. This soil, occupying a total of 1,152 acres, occurs in small narrow bodies bordering larger areas of flatter Denverton soils.

Denverton clay (adobe), rolling phase.—This phase represents areas of the soil type with undulating relief, slopes of 12 to

20 percent, and the same profile as in smoother normal areas. Because of the fairly short slopes of the rolling relief and the favorable physical condition of the entire soil profile, erosion is not very serious. Rain water is absorbed rapidly, and runoff is greatly reduced.

The surface soil is brown, grayish-brown, or rich-brown noncalcareous friable clay of adobe structure when dry. The material has excellent physical properties, easy to maintain even under cultivation. The subsoil is light-brown calcareous heavy clay, containing some mycelial lime in the upper part. It is more compact and cloddy than the surface soil. The lower subsoil is highly calcareous, with large soft blotches of lime. The aggregates are coated with colloidal stains, and there are some dark shiny manganese stains in the lower part of the subsoil and in the upper part of the underlying parent material. The parent material consists of light grayish-brown calcareous stratified heavy-textured sediments, usually with considerable well-rounded gravel. At times the upper part is somewhat cemented by lime.

The natural cover of grass grows well during the rainy season, furnishing very good range pasture for both sheep and cattle. Some dry-farmed grain is raised, but in this area grain yields are more dependent upon the quantity and distribution of rainfall than on the soil type. A total of 2,176 acres is mapped along the western edge of the valley bordering the hills and extending intermittently from the northern to the southern boundaries of the survey.

Denverton gravelly clay, hilly phase.—This phase occurs on slopes of 20 to 40 percent. The surface soil is grayish-brown or brown noncalcareous clay, which often develops shrinkage cracks and an adobe-like structure during dry summers. Many rounded particles of gravel, mostly quartzite, are on the surface and throughout the soil. The subsoil is brown calcareous heavy-textured material with considerable gravel. It may be relatively compact or loose and friable and is extremely variable in thickness. The underlying parent material, consisting of light-brown calcareous stratified gravelly clay sediments, may be immediately under the surface soil or may not be encountered to depths of many feet.

Erosion is not excessive, but there is some sheet erosion and occasional gullying and areas where considerable soil accumulation is at the base of slopes.

A total of 448 acres lies along the western side of the valley from Crow Creek northward. The grass cover is fairly dense and as the soil is considered one of the better for pasture, it is used entirely for this purpose.

Denverton gravelly clay, rolling phase.—This phase occupies high alluvial terraces incised by drainageways that give rise to a rolling relief. The slopes are broad but fairly steep, and the profiles are very indefinite and extremely variable. Broad ridge tops make up 20 to 40 percent of the areal extent.

The surface soil is a brown or grayish-brown intermittently calcareous gravelly clay. When dry this often develops shrinkage cracks approaching an adobe structure. Considerable quartzitic and well-rounded gravel is on the surface and throughout the soil material. When disturbed the soil breaks into soft clods that crumble readily to a friable granular condition under favorable moisture conditions and

cultivation. Many roots and some worm channels occur throughout the soil mass.

The upper subsoil, occurring at a depth of 6 to 15 inches, is brown or rich-brown calcareous clay with some development of structure and colloidal stains. The soil aggregates are larger and firmer than those of the surface soil, yet they are broken down with only moderate pressure to a granular condition. A little segregated lime occurring in thin seams forms a mycelial pattern in the lower part. Roots and worm channels are almost as numerous as in the surface soil and are lined with colloidal stains. At a depth of 20 to 36 inches the lower subsoil layer is rich-brown or light reddish-brown highly calcareous clay with much colloidal staining. Lime occurs in seams and in large soft nodules. The aggregates are large and irregular in shape and somewhat compact but have many lines of weakness along the lime seams. When moist these are friable but they are harder when dry. The number of roots decreases rapidly and insect burrowings become infrequent with increase in depth. The lower part is less compact and grades into the parent material of calcareous gravelly deposits, usually of clay or clay loam texture. Much lime coating is on the gravel, and occasionally the lime partly cements the material.

Erosion is slight on the broad flat tops but more pronounced on the steeper slopes, although not severe. There is some gullying and very little development of pot holes, but sheet erosion is most pronounced.

This soil is used almost entirely for sheep pasture. Grass grows in abundance and is of good quality. Some bodies of moderate extent border the valley from the northern part of this area southward nearly to Orestimba Creek. A total of 832 acres is mapped.

Denverton gravelly clay, steep phase.—This phase represents areas of the soil type in which the slopes exceed 40 percent. In these areas an original broad gravelly terrace has been dissected by drainage channels. The profile is extremely variable; in places there is only a thin mantle of soil over the parent material. Some sheet erosion and occasional deep gullies are present in most places. The lower part of the slopes has a much thicker soil mantle than the upper. Gullies, although infrequent, usually cut deep into the parent material, which appears to be more erosive than the soil mantle.

The surface soil is grayish-brown or brown noncalcareous gravelly clay. The subsoil is light-brown gravelly clay that may be somewhat more compact. This layer is calcareous, and in some places has fair depth but in others may be practically nothing. The parent material is composed of stratified calcareous layers of gravelly clay. At times the upper part is somewhat cemented with lime.

The grass cover is not so dense as on the flatter ridge tops, but it is fairly heavy and of good quality. The total area of 1,536 acres is closely associated with the hilly and rolling phases.

Diablo clay (adobe).—The surface soil is very dark-gray or black clay of dense highly colloidal and noncalcareous character. During the dry summer season it shrinks and develops a pronounced adobe structure with deep wide cracks forming large irregular blocks. Subsequent drying and shrinking result in a mass of small irregular or roughly cubical aggregates 1 to 2 inches in diameter, firm and hard when dry but sticky when wet. Small rock fragments occur in this

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layer. Roots are numerous and well distributed throughout, and a moderate quantity of organic matter is present.

The dark-gray heavy compact clay subsoil with colloidal staining occurs at a depth of 6 to 12 inches. The surface cracks extend nearly through this layer, giving it a somewhat prismatic structure. When disturbed this breaks into hard fairly large firm blocks with some colloidal staining on the surface of the aggregates. Roots extend through the aggregates and are not concentrated in the cracks. This layer becomes lighter in color, and the quantity of rock fragments, some of which are coated with lime, increases with depth. The lower few inches of this layer are calcareous and somewhat intermixed with the shattered bedrock. Here the rock fragments are all coated with lime. Some of the surface cracks extend down into this lower part and the sloughing of the darker colored surface material down the cracks when dry gives this layer a mottled appearance.

The parent bedrock, occurring at a depth of 18 to 40 inches, is light-gray or gray shale or argillaceous sandstone. Fairly soft in the upper part, it becomes harder with depth and includes some soil material that has worked down into the cracks and some lime coating on the rock surface and in the cracks. The harder bedrock itself may or may not be calcareous.

This soil has hilly relief with broad rounding ridges or moundlike tops and broad sloping sides that are covered with grass and used mainly for range pasture. The carrying capacity is high and the quality of feed good. Despite its heavy texture, this soil absorbs rain water readily. Erosion is slight, as the water sinks deep into the cracks, where most of it is absorbed.

This type is much like Altamont clay (adobe), but it is darker, less extensive, and does not occur on such steep slopes. A total area of 448 acres is mapped on the lower hills between Crow and Garzas Creeks.

Diablo clay (adobe), rolling phase.—The slope of this phase is less than 15 percent. The profile is a little deeper and the subsoil more compact than in the normal phase. Erosion is slight with occasional small gullies.

The surface soil is dark-gray to black noncalcareous clay with an adobe structure underlain by dark-gray or dull-gray compact calcareous clay with a blocky structure. Some segregated lime occurs in the lower subsoil layer. The bedrock is light-gray shale that may or may not be calcareous and the upper part is weathered and shattered and has lime coating the rock fragments.

Most of the soil is used for grazing, although it is suitable for dry farming to grain. The total area of 704 acres occurs in small bodies along the eastern border of the hills from Crow Creek southward.

Dinuba fine sand.—To a depth of 20 to 36 inches the surface soil is dull-brown or brown noncalcareous fine sand of single-grained character. The soil is micaceous, mildly acid, and is permeated by plant roots.

The subsoil, to a depth of 40 to 70 inches, is brown or grayish-brown noncalcareous fine sand or fine sandy loam. This material has little structure in place but when disturbed forms irregular soft clods

that are sufficiently firm to preserve the fine pores. These clods crumble readily to single-grained structureless material. Roots decrease in number with depth, and the reaction is about neutral. The lower subsoil consists of a series of lenses of calcareous gray hardpanlike material, with intervening gray calcareous loam or clay loam material containing some hard calcareous nodules. The lenses are of finer texture than the soil material and usually extend to depths of more than 6 feet.

This soil occurs near the river at slightly higher elevations than the Columbia soils but is subject to occasional overflow. It has a slightly undulating surface that has been modified to a minor extent by wind action. The soil may be slightly affected by alkali, but in this area the salts are not in sufficient concentration to interfere seriously with growing plants.

A total of 256 acres is mapped. One body lies about 1 mile north of Grayson and another 3 miles east of Patterson. This soil is used for grapes, grain, and alfalfa. Grapes do very well and alfalfa and grain do moderately well, but the yield is less than on the recent alluvial soils of the Mocho and Sorrento series.

Dublin clay (adobe).—To a depth of about 12 inches the surface soil is very dark-gray to black, noncalcareous, slightly acid, and contains some organic matter. When dry, large cracks separate the soil into rather regular blocks, which develop a secondary checking and cracking by means of which the surface soil breaks into small aggregates and forms a favorable tilth under cultivation. This heavy-textured soil, however, is very plastic when wet and becomes puddled and tight if not properly handled. Many fine roots and frequent worm holes as well as a few scattered white shale fragments are in this layer.

The upper subsoil is of similar or darker color, is neutral in reaction, and is considerably more dense, owing mainly to extremely heavy texture and highly colloidal character. During dry periods surface cracks extend through this layer, and the subsoil breaks into large irregular hard blocks or clods.

At depths of 2½ to 5 feet, the subsoil is dull gray, slightly alkaline, and contains many light-gray shale fragments. There is no definite structure in this layer and the material is less dense, but still contains a large quantity of clay. When dry, some of the dark-colored surface soil falls into the cracks extending into this layer and gives it a mottled appearance. Roots and water penetrate this subsoil fairly easily and it retains moisture well.

The underlying substratum is composed of a yellowish-brown friable material containing a small quantity of crystallized gypsum but no lime carbonate. This material may be stratified with coarse sediments and in some places a few rounded particles of gravel occur. At this depth there is no definite structure and only a few light-colored shale fragments are present.

The soil is fairly well suited to agriculture, but the tough subsoil restricts its usage to shallow-rooted crops. As irrigation water is not available in this area it is all dry-farmed to grain. Yields are dependent upon winter rain, and they are generally fair to good. A total of 256 acres is mapped on small alluvial fans of low gradient at the base of ridges.

Esparto gravelly sandy loam.—The surface soil to a depth of about 12 inches is grayish-brown friable gravelly sandy loam of slightly acid reaction. A large cultivated body takes on a brown or reddish-brown color. The soil is fairly easily puddled and bakes hard on the surface in some places. Drainage is usually good and no areas of "alkali" accumulation were observed.

The upper subsoil layer is brown, slightly acid, somewhat heavier textured than the surface soil, and extends to an average depth of 36 inches. This layer is slightly more compact and breaks into irregular-shaped aggregates, slightly stained with colloids and brittle but easily crumbled. The layer is readily penetrated by roots and water and is retentive of moisture. To a depth of about 45 inches the lower subsoil layer is a light-brown neutral soil and generally of the same texture as the upper subsoil. This layer is somewhat more compact, with a considerable quantity of colloidal staining on the soil aggregates; has no definite structure in place and when disturbed is easily crumbled to a granular mass; retains moisture well; and contains many root and worm holes throughout.

The underlying substratum consists of light grayish-brown stratified material composed of gravelly and sandy layers. There may be a few rounded gravel particles lightly coated with lime carbonate, but the fine material is noncalcareous.

The soil is dry-farmed to grain (pl. 2, *B*) and fair yields are obtained when winter rains are favorable. If irrigation water were available, it could be used for beans, alfalfa, or orchards. The gravel is small and not in sufficient quantity to interfere seriously with tillage operations. A total of 1,664 acres is mapped. A fairly large and representative body is located about 2½ miles west of Newman.

A few small areas about 3 miles southwest and 8 miles northwest of Newman, which are of heavier texture than the typical soil, are included.

Gaviota fine sandy loam.—The 5- to 12-inch surface soil is dull grayish brown or grayish brown, slightly acid or neutral, usually containing a number of angular sandstone fragments, some of which are coated with lime. When disturbed the soil breaks into soft clods that are easily reduced to an almost single-grained condition. Many grass roots are in this layer.

The subsoil is not very distinct, but at a depth of 8 to 18 inches it is slightly lighter brown and of heavier texture than the surface soil. This layer is calcareous and has more rock fragments than the surface layer, and most of them are coated with lime. It has little colloidal staining, and roots are numerous.

The upper part of the parent bedrock is soft, crumbled, intermixed with soil material, and has some roots in the upper part. Some seams of lime have accumulated in the cracks. Bedrock becomes more massive, harder, and noncalcareous with depth.

The native vegetation consists of grass and associated herbaceous plants. Most of the land is used for sheep pasture, but a few small areas are sometimes in dry-farmed grain. Owing to low rainfall and shallow depth of the soil the yields are low and seldom profitable.

This soil occurs on areas of hilly to mountainous relief in the western part of the area between Puerto and Garzas Creeks. A total of 3,136

acres is mapped in association with the Altamont, Crow Hill, and Kettleman series.

A few small areas of loam are included—the largest (about 70 acres) along the line between secs. 31 and 32, T. 7 S., R. 8 E.; another (about 30 acres) southeast of the center of sec. 35, T. 6 S., R. 7 E. These areas differ only in having a slightly heavier texture in the surface soil.

Gaviota fine sandy loam, eroded phase.—This phase is a combination of sheet and gully erosion. The relief is hilly with well-rounded tops and slopes of 15 to 40 percent. For the most part erosion is moderately severe and is manifest even under grass cover by irregular small rills parallel to the slope and by larger gullies. Severe erosion occurs in smaller localized areas, many of which have been used as bedding grounds for sheep, but in a few areas where deep gullies and pot holes occur along fault lines, the faulting has shattered the underlying bedrock, making it much softer and more easily eroded.

The surface soil is brown to grayish-brown neutral to slightly acid fine sandy loam in which the surface is cut by erosion. The subsoil is a lighter brown, calcareous, and where the soil is sufficiently deep there is some evidence of profile development. It is more compact than the surface soil and the irregular-shaped aggregates are coated with colloidal stains. Segregated lime and at times a little crystalline gypsum are found in this layer. The upper part of the underlying bedrock is crumbled and weathered, and occasionally crystalline gypsum occurs in the cracks. The lower bedrock is usually noncalcareous and massive.

Most of the areas are used for grazing, but a few bodies are used occasionally for dry farming to grain. The grazed areas are pastured mostly by sheep, and overgrazing is common. More careful practices would decrease erosion and probably eventually increase the carrying capacity for livestock.

A total of 1,600 acres is mapped, extending southward in narrow bands from Puerto Creek to Garzas Creek. Small areas are on either side of Orestimba Creek not far from where it enters the valley.

Gaviota fine sandy loam, eroded rock-outcrop phase.—The surface soil is brown to grayish-brown noncalcareous sandy loam. The subsoil is calcareous and of similar texture but of slightly lighter color. There is very little soil development in this shallow profile. The bedrock is not weathered so deeply as in the Gaviota soils that have not been subjected to so severe erosion, and the soil mantle is thinner. The erosion is mostly sheet erosion that has removed much of the thin soil mantle. The parent sandstone dips to the east and much of it occurs along the western hill slopes, where bedrock is exposed and the soils are thin and rock outcrop frequent.

The sparse natural vegetative cover is of grass and shrubs. The soil is used for grazing sheep and has a low carrying capacity. It occurs along the western edge of the area, extending from Orestimba Creek northward. A total of 4,608 acres is mapped.

Gaviota fine sandy loam, eroded steep phase.—On slopes, which are in excess of 40 percent, the surface has been subjected to moderately severe to severe erosion. Sheet erosion is common to a moderately severe degree throughout, with smaller localized areas of severe gullies

and pot holes. Much of the erosion is the result of overgrazing, which so depletes the vegetation as to reduce greatly the protective cover, although there are areas where faulting has so shattered the bedrock as to permit much greater damage by erosion than would otherwise occur.

This phase consists of brown to grayish-brown noncalcareous surface soil with slightly lighter colored calcareous subsoil resting at variable depths on sandstone bedrock. The upper part of the bedrock is shattered and has some lime in seams. The lower part is massive and noncalcareous sandstone.

This soil is used only for grazing, but the grass cover is poor. It is associated with the other phases of the Gaviota series in long narrow bodies between Crow and Puerto Creeks. A total of 1,280 acres is mapped.

Gaviota fine sandy loam, rock-outcrop phase.—This phase differs from the normal phase in that it has a more shallow profile and steeper relief, the surface is broken by frequent outcrops of bedrock, the soil is of slightly grayer color, and erosion is much more severe. More than 25 percent of the surface has outcrops of bedrock. These outcrops are mostly of light-gray sandstone. In many areas streaks of iron precipitation and iron concretions occur in the bedrock and on the surface, where they have accumulated by washing away the fine soil material.

The average depth of the soil material is about 10 inches, with the lower part exposed in many erosion scars. Where erosion is not severe the color under grass is dull grayish brown or grayish brown, but the eroded spots are light grayish brown. As the soil is very shallow, it has no definitely developed profile.

This soil supports only a sparse cover of grasses with a few scattered shrubs and is used entirely as range pasture for cattle and sheep. It is somewhat overgrazed and highly erosive. Associated with other soils of the Gaviota series it is developed most frequently on the western slopes of the hills, where the underlying strata are exposed. A total of 5,888 acres is mapped.

Gaviota fine sandy loam, rolling phase.—Occurring on slopes of less than 15 percent, this phase is slightly deeper and the subsoil is somewhat more compact than in the normal phase.

The surface soil is dull-brown or grayish-brown neutral or slightly acid fine sandy loam of soft cloddy or single-grain structure. The subsoil is slightly lighter in color, more compact, and usually has a somewhat heavier texture. The structure is cloddy and the aggregates are irregular in shape and thinly coated with colloidal coatings. This layer is calcareous and thin seams of segregated lime are found in the lower part. The subsoil grades into the upper parent material, which is composed of shattered and crumbled sandstone rocks coated with lime. The cracks in the rocks also have thin lime seams. They get smaller and less numerous with depth and the rock more massive.

Although much of this soil is used only for grazing, mostly by sheep, a higher proportion is used for dry-farmed grain than in the normal phase. Yields of grain are fair in favorable seasons but in unfavorable seasons the crop is not worth harvesting. The increased pasture, however, partly pays for the cost of seeding.

A total of 1,408 acres is mapped, mostly between Orestimba and Garzas Creeks.

Gaviota fine sandy loam, steep phase.—The surface soil is brown or grayish-brown noncalcareous sandy loam, with soft cloddy or single-grained structure. The subsoil is slightly lighter in color, calcareous, and may be somewhat more compact. The texture may or may not be heavier, depending on depth to bedrock, which is extremely variable and ranges from a few inches to several feet. The upper bedrock is soft and shattered, with some lime seams along the cracks, whereas the bedrock proper is massive noncalcareous sandstone.

This soil with slopes of more than 40 percent is too steep to be used for farming. The profile is similar to that of the normal phase, but is more variable in depth and has a few more areas of rock outcrop. Erosion is slight to moderate, with occasional gullies.

The natural cover is grass with a few areas of brush. It is used mainly as grazing land, mostly for sheep. This phase occurs in several long narrow bodies between Crow and Puerto Creeks and has a total area of 512 acres.

Herdlyn loam.—To an average depth of 8 inches the surface soil is dull-brown loam, slightly acid in reaction, and moderately friable. To a depth of about 30 inches the upper subsoil is dark brown, noncalcareous, and generally heavier textured than the surface soil. This layer is very dense and compact with a definite prismatic structure. The prisms are roughly 7 inches long and 5 inches in diameter, with sharp angular corners and coated with colloidal stains. Despite the density of this layer, the roots are fairly well distributed throughout and only slightly concentrated along the breakage planes. The lower subsoil is yellowish brown or light brown and contains considerable quantities of segregated lime in soft nodular form. This layer extends to a depth of 50 to 60 inches, and although generally lighter textured than the upper subsoil, it is compact, with a slight suggestion of cubical structure, and breaks into blocks that are roughly cubical and covered with deep colloidal stainings. Many of the cracks and small root channels are lined with faint iron and manganese stains. The underlying substratum is light yellowish brown and somewhat lighter textured than the material above and moderately friable. It extends to undetermined depth and is intermittently calcareous and only slightly compact. No roots penetrate to this depth and the soil is usually dry.

This gently sloping soil, which is one of the most distinctive in the area, is dry-farmed to grain and gives fair yields when winter rains are favorable. Owing to dense subsoil only about the top 8 inches can be readily worked, which definitely limits it to shallow-rooted crops or pasture. A representative body of its 192 acres is about 2 miles southwest of Newman.

Kettleman clay loam.—The 4- to 18-inch surface soil is light yellowish gray and calcareous and when disturbed breaks into soft friable clods that can be easily crushed into a granular condition. The quantity of organic matter is low, but roots are numerous and well distributed throughout. The entire soil profile is usually shallow. The subsoil is brownish-gray to light yellowish-brown highly calcareous heavy clay loam or clay, very friable, stained with colloids, and contains a little mycelial lime and occasionally some gypsum crystals.

Roots are not so numerous as in the surface soil but are well distributed throughout this layer. Some rounded gravel, most of which is coated with lime, is present throughout the profile. At a depth of 10 to 30 inches the parent bedrock is soft shale with some embedded rounded gravel. It is rather badly crumbled and generally calcareous in the upper part. A few roots also extend into this part.

The slopes are steep, and the strata of bedrock that dips to the east are somewhat exposed. Uplifting and folding have shattered the bedrock and promoted erosion. Sheet erosion, gullying, and development of pot holes are evident.

Vegetation is generally fair but in spots it is very sparse. It consists mostly of grasses and associated plants with a little scattered brush or shrubs. The soil is used only as range pasture for sheep and is subject to overgrazing, which greatly increases erosion. Shattered bedrock renders effective erosion control by mechanical or engineering structures very difficult. Careful control of grazing is the only control method practicable. Most of the soil occurs on the western slope of the first ridge paralleling the valley of the San Joaquin River. It has a total area of 1,792 acres.

Kettleman clay loam, eroded phase.—This phase represents areas of the soil type that have been subjected to moderately severe sheet erosion, usually accompanied by occasional deep gullies.

The surface soil is light yellowish-brown or brownish-gray calcareous extremely friable heavy clay loam. The subsoil is slightly lighter in color and is a highly calcareous and friable clay, with some evidence of colloidal stainings on the surface of the soft aggregates. Some segregated lime and usually some gypsum crystals occur in the lower part of the subsoil and in the soft weathered part of the bedrock. The weathering in the bedrock is fairly deep, and this weathered material is as easily eroded as the soil itself.

The natural cover is grass with some areas of brush or shrubs. The land is used entirely for grazing sheep, and overgrazing, which increases erosion, is very common. Because of the deeply weathered bedrock, fairly deep gullies are developed. These are difficult to control mechanically, and it is more practical to lessen erosion by controlling grazing. The 2,368 acres mapped occur in a number of long narrow bodies in the northern half of the area.

Kettleman clay loam, eroded steep phase.—This phase represents areas of the soil type where the slope is more than 40 percent and erosion is moderately severe to severe.

The surface is light yellowish-brown or pale brownish-gray calcareous friable clay loam. The subsoil is of similar or slightly lighter colored calcareous friable clay loam, with some segregated lime and crystalline gypsum. Bedrock is normally soft and deeply weathered. Segregated lime and gypsum occur in the weathered part but the harder bedrock may or may not be calcareous.

Vegetation is thin and consists of grasses with some areas of shrubs. The soil has been subjected to moderately severe sheet erosion, with occasional deep gullies. A few small areas are eroded more severely and many deep gullies and some pot holes have been developed. These areas of more severe erosion may have developed in spots used as bedding grounds for sheep or in places where faulting has shattered

the bedrock. Mechanical control would be impractical especially in areas where the bedrock has been shattered by faulting. Erosion could be most effectively managed by controlling grazing.

This soil occurs in long narrow bodies in the hilly part of the area. These parallel the edge of the valley and occur more frequently on the western slopes, which are usually steeper than the eastern. The bedrock strata dip to the east and are exposed along the western slopes of shallow soil. A total of 1,664 acres is mapped.

Kettleman clay loam, rock-outcrop phase.—This phase is much like the normal phase in profile characteristics, but usually occurs on steeper slopes and is shallower. At least 25 percent of the areal extent is composed of bedrock and the rest of soil of extremely variable depth.

The surface soil and the subsoil are light yellowish-brown or pale brownish-gray calcareous friable clay loam. The strata all dip to the east at variable angles. The exposed bedrock is formed by outcropping of tilted strata of shale and shale and sandstone conglomerates. These rocks have been much shattered and crumbled in the tilting and are easily broken down. The soil and rock materials are erodible, and many gullies have developed.

This soil produces only sparse pasture and is economically unimportant. Erosion is severe, and the soil areas are of very little value. All the soil occurs on the western slopes of the first ridge paralleling the valley. A total of 448 acres is mapped.

Kettleman clay loam, steep phase.—The slope of this phase is more than 40 percent, and erosion is moderate or slight. The depth of the soil profile is somewhat more variable than in the normal phase. The surface soil is light yellowish-brown to light brownish-gray friable calcareous clay loam. The subsoil is light yellowish-brown to light brownish-gray friable clay or clay loam, but may have some colloidal stainings on the soft aggregates. Segregated lime and often some crystalline gypsum occur in the lower part of the subsoil and in the weathered parent material. The bedrock is soft light-gray shale that may or may not be calcareous.

The vegetation, consisting of native grasses, is not very dense, yet where not overgrazed it offers fairly effective protection against erosion. Erosion is not now excessive but as the soft crumbly consistence of the soil favors erosion, great care must be exercised to prevent overgrazing. A total of 576 acres is mapped.

Kettleman fine sandy loam.—The surface soil is light grayish-brown to light yellowish-brown calcareous friable fine sandy loam forming soft cloddy or granular structure when disturbed. This layer has many grass roots, some insect burrowings, and a few lime-coated rock fragments. At a depth of 6 to 16 inches the subsoil is light-brown or light grayish-brown calcareous heavy fine sandy loam or loam. In the deeper areas the soil aggregates are somewhat compact and have some colloidal stains. Roots are numerous, but there are not so many as in the surface soil. Some worm channels lined with colloidal stains occur in this layer. The color becomes lighter and the quantity of rock fragments increases with depth. Bedrock is encountered at a depth of 8 to 40 inches, the upper part of it shattered and containing some soil material and roots that have found their way into

the cracks. Considerable lime coating on the rock fragments and some gypsum crystals are in the soil material. The deeper bedrock consists of light-colored but fairly soft and usually noncalcareous sandstone.

The profile varies in depth, with the deeper areas on the eastern slopes. The relief is hilly with steeper western slopes. Sheet erosion is usually slight to moderate, but there are occasional gullies on the eastern slopes. Erosion is normally more severe on the steeper western slopes, where the soil is shallower and the vegetation less dense.

This type is used almost exclusively as range pasture for sheep, but small areas are sometimes included in dry-farmed grain tracts in association with more favorable adjacent soils. Grain yields are low.

This soil is closely associated with the fine sandy loam type of the Gaviota series. It has a total area of 448 acres in the hilly part of the area south of Puerto Creek.

Kettleman fine sandy loam, eroded phase.—The slope of this phase is 15 to 40 percent, and erosion is excessive. The surface soil is light yellowish-brown calcareous fine sandy loam of soft cloddy or single-grained condition when disturbed. The subsoil is of slightly lighter color and may have some colloidal staining on the surface of the soft aggregates. A greater quantity of lime is in the subsoil and at times some gypsum crystals are present in the lower part of the subsoil and in the soft weathered upper part of the sandstone bedrock.

Sheet erosion prevoils, largely as the result of overgrazing, particularly by sheep. Some areas have deep gullies. The protective cover, mostly of grass, is not very dense and when overgrazed is not sufficient to prevent washing of the soil material. An aggregate area of 768 acres is mapped—mostly in rather long narrow bodies south of Puerto Creek paralleling the edge of the valley.

Kettleman fine sandy loam, eroded steep phase.—This phase represents areas of the soil type in which the slope is more than 40 percent and erosion is excessive. The surface soil is light yellowish-brown to light yellowish-gray calcareous friable fine sandy loam. The subsoil is similar to the surface layer in physical properties but is slightly lighter in color and has a higher lime content. Some segregated lime and at times some crystalline gypsum are present in the lower subsoil layer and in the weathered upper part of the parent material. The bedrock is rather softly consolidated light-gray sandstone.

This soil is covered by grass or shrubs and is used entirely for grazing, mostly by sheep. It occurs mostly on west slopes, which are usually steeper than the east slopes of the same ridges. The rock strata dip to the east, and the west slopes cut across the strata, but on the east slopes the strata are more nearly parallel to the surface. The soil on west slopes is shallower and supports less vegetation. Water runs off faster and causes more damage by erosion, mostly of the sheet-erosion type, with some gullies, and is especially severe on a few small areas on old sheep-bedding grounds. Deep gullies accompanied by development of pot holes or landslides occur on areas where faulting has shattered the bedrock to considerable depths.

This soil occupies a total of 1,216 acres in long narrow bodies south of Crow Creek.

Kettleman fine sandy loam, rock-outcrop phase.—This phase includes areas of both sandy loam and fine sandy loam. The soil is essentially the same as the normal phase, but it is normally shallower and at least 25 percent of the surface is occupied by outcrop of bedrock. Often there is very little difference between the surface and subsoil material.

Occupying a total area of 2,816 acres, this phase is more extensive than the normal phase. The relief is usually more rough and irregular, sheet erosion is moderate to severe, but gully erosion is less severe. The areas are often covered with brush and are used entirely for sheep pasture.

Kettleman fine sandy loam, rolling phase.—This phase represents smoother areas of the soil type having slopes of less than 15 percent. The surface soil is light grayish-brown or light brownish-gray calcareous fine sandy loam of single-grained or softly cloddy condition when disturbed. The subsoil is light grayish-brown calcareous fine sandy loam or loam with some colloidal staining. Some segregated lime and crystalline gypsum are often in the lower part of the subsoil and in the soft weathered parent material, which consists of softly consolidated sandstone.

Its low hilly areas, which border the valleys, are used almost exclusively for pasture. Some are planted to grain, but the yields are dependent to a large extent on the seasonal rainfall, which is not sufficient to insure a grain crop except in unusually favorable seasons. A total of 512 acres is mapped.

Made land.—This type of land is confined to a few small scattered areas of gravel pits and gravel stock piles in the channel of Orestimba Creek and on the banks. A total of 64 acres is mapped. It has considerable commercial but no agricultural value.

Merced clay loam.—The surface soil is dark-gray noncalcareous clay loam or heavy clay loam with a moderate quantity of organic matter. Under cultivation it breaks into irregular and moderately firm clods that soften when wet. Many roots occur throughout.

At a depth of 8 to 20 inches the upper subsoil layer is dark-gray or black somewhat compact noncalcareous clay. There is a suggestion of vertical cracking and the soil aggregates are large and more firm than those of the surface soil. They are coated with colloidal stains, and some colloidal material lines the root and worm cavities. The color is slightly lighter in the lower part, where the structure is less pronounced. The number of roots decreases with depth and a few dull mottlings are found near the lower part. At a depth of 20 to 36 inches the brownish-gray calcareous clay lower subsoil layer is encountered. This material is compact and has considerable colloidal staining on the soil aggregates and lining the root cavities. The aggregates are smaller than in the layer above, of irregular shape, and are more easily crushed. Considerable segregated lime usually occurs in fairly large blotches and soft nodules, together with a few dull-gray mottlings. Occasionally some partly decomposed organic matter gives this layer a distinct mottled appearance.

The degree of density and number of roots decrease with depth, and the material grades into the parent material of dull-gray or dull greenish-gray highly calcareous stratified sediments of medium to

heavy texture. Some hard lime-silica cemented pellets and occasionally some lenses of cementation are present. These are more numerous in this area and especially in the vicinity of Hills Ferry than in other parts of the State.

Because of the heavy and somewhat dense subsoil, drainage is somewhat restricted. Under natural conditions the land is subject to overflow and even though partly protected it is flooded in seasons of extremely high water. Artificial drainage is necessary to farm this soil successfully.

This type is used mostly for pasture. It remains moist in spring for some time after the soils on the alluvial fans have dried out, and the grasses are green until midsummer. Only a few small spots of strong alkali accumulation occur, but there are larger areas of slight and moderate salt concentration that somewhat impair the value of this soil for pasture and farming. Fairly good yields of grain are obtained on some areas. This type, occupying a total of 1,216 acres, lies in the axis of the valley in basinlike areas and has a high water table.

Small areas of heavier silty clay texture are included with this soil type in the vicinity of Upper White Lake and near the northeast corner of the El Solyo Ranch.

Mocho clay loam.—The surface soil is light grayish brown and calcareous and varies in thickness from 10 to 25 inches. Soft clods are formed when the soil is plowed, but they are readily broken down to a granular tilth. A weak crust develops on the surface after irrigation or rain. This layer contains enough colloidal clay to become moderately plastic when wet and to have a plow sole develop if worked when too moist. The calcareous subsoil is light brown and extends to depths of more than 6 feet. The lime carbonate content increases with depth and some mycelial lime occurs in the lower part. It is structureless and moderately friable when dry but somewhat plastic when wet. Moisture is fairly well retained and there are many preserved root holes and insect burrowings.

Some of the soil has been dry-farmed to grain with good yields. Most of it, however, is under irrigation to beans, peas, and miscellaneous truck crops, which consistently yield better than average. Selection of suitable crops depends more on local climatic conditions than on the soil itself. It is highly productive and has excellent physical properties and a high agricultural value. Fairly large nearly level bodies occur on the upper part of the alluvial fans west of Patterson. A total of 2,752 acres is mapped.

Mocho fine sandy loam.—The deep friable 15- to 35-inch surface soil is calcareous and generally light grayish brown. There is some tendency for a weak crust to form on the surface, but the soil does not readily form a plow sole under cultivation. The subsoil is usually lighter brown than the surface soil and is often stratified with coarser material. It contains appreciable quantities of disseminated lime and extends to depths of more than 6 feet. The subsoil is consistently loose and friable with numerous root holes and insect burrows that are fairly well preserved. At the lower depths the soil material often contains mycelial lime.

One of the better agricultural soils in the State, it will grow successfully any irrigated crop climatically adapted to this area. Dry farm-

ing yields are fair to good but not high because the soil is less retentive of moisture than one of heavier texture. The surface is nearly level.

A total of 3,648 acres is mapped, most of it near the channels of Orestimba, Crow, and Ingram Creeks and other small streams.

Mocho gravelly loamy sand.—The 6- to 20-inch surface soil consists of a course-textured layer, mainly sand and gravel, and contains small quantities of disseminated lime carbonate. The color is generally light grayish brown. The subsoil, extending to a depth of 2 to 6 feet, depending upon the location, is lighter brown, contains more lime, and is stratified with gravelly and sandy materials. This soil is of recent accumulation and without visible evidence of profile development.

Only areas of the deeper soil can be used for cultivated crops. In the absence of irrigation water, these are dry-farmed to grain, but the yields are low. The coarse-textured shallow areas are not suited to dry farming because of low water-holding capacity, but even if irrigation were possible, the large proportion of gravel would interfere with tillage operations and exclude many crops.

This soil occupies a total of 576 acres, mainly in the small islands in the wash of Orestimba Creek and in small areas along Ingram Creek The soil is shallow and only slightly better than riverwash, especially the areas along Orestimba Creek. Those along Ingram Creek near the mouth of the Canyon consist of deeper soil materials.

Ohmer gravelly loam.—The surface soil is dark-brown or dark grayish-brown mildly acid gravelly loam of blocky structure. It is fairly friable when moist but bakes hard on drying and breaks into hard angular clods. Considerable gravel, most of which is of rounded quartzite or hard metamorphosed sedimentary rocks, is on the surface and throughout the soil material. There are many roots but few insect and worm holes through this layer and the upper subsoil.

To a depth of 20 to 30 inches the upper subsoil is rich-brown or reddish-brown mildly acid very compact gravelly clay with a prismatic structure in the upper part and a rather cubical structure in the lower. The soil aggregates are hard when dry, and heavily coated with colloidal stains, and roots have a tendency to concentrate in the cracks. The material is very dense and tough, of a cheesy consistence when moist and very sticky and plastic when wet. The prisms are 3 or 4 inches long and 1½ or 2 inches in diameter, and the cubical aggregates 1½ or 2 inches square. The lower subsoil is a reddish-brown or brownish-red noncalcareous gravelly clay of about neutral reaction. It is dense and compact and breaks into irregular-shaped angular clods coated with colloidal stains and having some manganese stains in the interior. This layer, which extends to depths of 40 to 66 inches, has very few roots. The lower part becomes lighter in color and some lime coatings occur on a few of the gravel particles, although the soil itself is noncalcareous.

The underlying parent material consists of stratified terrace deposits of gravelly clay loam or gravelly clay. These are normally noncalcareous but some of the gravel is coated with lime.

Developed on terrace remnants similar in position to the Denverton soils this soil occupies rolling ridge tops of 12 to 20 percent slope, supports a cover of grasses, and is used primarily for range pasture. A little grain is sometimes planted as a speculation based on chance of an unusually favorable seasonal rainfall. Usually these ventures

are unsuccessful but the increase in pasture partly if not wholly repays the cost of planting. Erosion is slight to moderate and there are very few gullies.

This soil is more suitable for range pasture than for any other use, although if summer fallowed it could produce 8 to 10 sacks of grain an acre. A total of 320 acres is mapped.

Ohmer gravelly loam, hilly phase.—The hilly phase represents areas of the soil type in which the slope is between 20 and 30 percent. There is more variation in the soil profile than in the other members of this series, but the sequence of layers is generally maintained. The surface soil is dark-brown or dark grayish-brown noncalcareous gravelly loam. The upper subsoil consists of rich-brown or reddish-brown noncalcareous gravelly clay having a prismatic structure and grading into a somewhat cubical structure in the lower part. The lower subsoil is massive gravelly clay and has considerable colloidal staining and streaks of manganese throughout. Although the soil is noncalcareous, the gravel may be coated with lime. The underlying parent material consists of light-brown or grayish-brown stratified gravelly terrace deposits, usually noncalcareous, although in places the gravel is coated with lime.

Erosion is not excessive, but there are occasional gullies. A total of 960 acres is mapped, all of which is used for range pasture. The grass cover is not so dense as on the Denverton soils but is fairly heavy and makes good pasture.

Ohmer gravelly loam, undulating phase.—This phase occurs on the flatter ridge tops where the slopes are up to 12 percent. The soil has a strongly developed profile with heavy claypan subsoil. Erosion is slight and gullies seldom occur. The surface soil is dark-brown or dark grayish-brown noncalcareous gravelly loam, friable when moist, but hard when dry. The upper subsoil layer consists of rich-brown or reddish-brown compact clay with a prismatic structure grading into cubical aggregates in the lower part. The aggregates are heavily coated with colloids, and the roots have a tendency to concentrate along the cracks. Less gravel is present than in any other layer throughout the profile. The lower subsoil is massive and compact, with much colloidal and some manganese stains. The material is noncalcareous, but the gravel may be coated with lime. The underlying parent material consists of old stratified gravelly clay loam or gravelly clay terrace deposits, usually noncalcareous, but occasionally with lime coating the gravel.

This phase is usually used for range pasture, but at times it may be plowed and planted to dry-farmed grain. In seasons when the quantity and distribution of rainfall are suitable, yields of 8 to 10 sacks of barley an acre may be obtained. Most of the 704 acres mapped is just north and south of Orestimba Creek.

Orestimba clay loam.—To an average depth of 7 inches the soil consists of grayish-brown noncalcareous or intermittently calcareous clay loam, containing slight to moderate quantities of organic matter. Enough colloidal material is present to make the soil fairly plastic when wet, and when dry the surface bakes to a firm crust and the soil forms large irregular clods when disturbed. Most areas contain moderate to slight concentrations of alkali. To a depth of about 30

inches the upper subsoil layer is dull grayish brown, noncalcareous, and of heavier texture than the surface soil. It is somewhat more compact and has a feebly developed blocky structure, with colloidal stains coating the soil aggregates. A few lime-cemented pellets are occasionally found at this depth. To a depth of about 4 feet the lower subsoil is brown or light brown, highly calcareous, and more compact but with no definite structure. This layer is often silty and mottled with iron stains and some dark-colored colloidal staining is on the soil aggregates. The lime carbonate is usually in the form of irregular-shaped hard pellets of variable size.

At depths of 48 inches or more, a concentration of hard and soft lime-carbonate pellets occur, formed at the general level of the water table. These are variable in size and shape, some being as much as half an inch in diameter and 1 inch long. The soil material beneath this layer is below the water table most of the time and is light brown with mottlings of bluish-gray iron stains. This is usually of medium silty texture but may be stratified with coarser textured material. Some lime pellets occur.

The content of salt and the poor drainage condition limit the agricultural use of the soil to pasture and to some dry-farmed grain where the salt is not so concentrated. A few areas are planted to alfalfa, but its yields are only fair and it dies out within 2 or 3 years. A total of 3,200 acres is mapped. Several rather large nearly level bodies occur east and northeast of Newman at the Merced County line.

Several large areas included with this soil in the vicinity of Hills Ferry are of somewhat heavier texture and denser character than typical.

Orestimba loam.—The 6-inch surface layer is grayish brown, noncalcareous, and moderately friable. The soil is generally cloddy when disturbed, and in many places a slight indication of vertical breakage is present and some fine roots concentrated along the breakage lines. To a depth of about 26 inches the upper subsoil is dark grayish brown, noncalcareous, and somewhat iron stained. This layer is generally of heavier texture than the surface soil and is slightly more compact, with an indistinct blocky structure. The soil aggregates are coated with dark colloidal stains, and many insect burrowings and grass roots are found at this depth. The material breaks into irregular-shaped clods that are firm but may be crumbled easily under pressure. To a depth of about 48 inches the lower subsoil is brown to light brown, highly calcareous, and slightly compact, but without a definite structure. The soil is generally silty and mottled with iron stains but relatively low in organic matter. The lime carbonate is generally in the form of soft irregular nodules a fourth to half an inch in diameter.

Below a depth of about 48 inches there is a zone of accumulated hard lime carbonate pellets, apparently precipitated from solution at the more or less constant level of the water table. These pellets are often a fourth to half an inch in diameter and a half to 1 inch long. The soil is silty at this depth and friable, with only a slight quantity of colloidal staining or mottling. At a lower depth the soil material is composed of stratified light-brown sediments that may contain lime-cemented pellets. This substratum is generally below the relatively high water table existing under this soil. In a few

areas the water table is deep enough not to interfere seriously with internal drainage but usually this type is poorly drained.

This soil is used for dry-farmed grain and a little alfalfa. Yields of the latter are only fair and the stands die out within 2 or 3 years. Most of the soil is more or less susceptible to accumulations of alkali in slight to moderate quantities, and under cultivation there is a tendency for the quantity of salts to increase. The land is best suited to pasture. Only 256 acres is mapped. Several representative bodies are east of Crows Landing along the lower fringes of the alluvial fans. The surface is nearly flat.

Pleasanton gravelly clay loam.—The surface soil to an average depth of about 8 inches is dull-brown noncalcareous slightly friable gravelly clay loam. Despite the high content of gravel the soil is somewhat plastic when wet and bakes on the surface when dry. A plow sole is readily formed if the soil is worked too wet, but some moisture is desirable to facilitate tillage operations. The upper subsoil layer is brown and moderately compact but has no definite structure. There is an appreciable quantity of colloidal staining of the soil aggregates and numerous root and insect holes that are fairly well preserved. The lower subsoil layer is less compact but there is more colloidal staining, and it is of slightly heavier texture and more retentive of moisture. Roots and water penetrate to this depth fairly easily. Below 36 or 40 inches is a substratum of loose stratified gravelly material of variable texture. The gravel is often lightly coated with lime carbonate, but the soil material is noncalcareous. In some places the gravel is weakly cemented together in a soft semihardpan formation at variable depths, usually below 5 feet.

This is a fairly good soil but somewhat limited in agricultural use by the high gravel content and moderately compact subsoil. Beans and alfalfa are now grown in the irrigated areas and fair yields are obtained. Because of the somewhat undulating surface relief the cost of leveling for irrigation is relatively high. A total of 3,648 acres is mapped. Two large bodies are just south of Westley.

Pleasanton gravelly sandy loam.—To a depth of about 8 inches the type consists of dull-brown noncalcareous friable sandy loam, containing many small and medium-sized rounded particles of gravel of hard quartzitic material. The surface soil tends to pack readily and in some areas bakes when dry, forming a hard crust, though water and roots usually penetrate it readily. The soil is free from injurious accumulations of salts.

At a depth of about 18 inches the upper subsoil is brown, noncalcareous moderately compact, and of somewhat heavier texture. Some colloidal staining is on the soil aggregates, but there is no definite structure in this layer. It is well permeated with root holes and is fairly retentive of moisture. To a depth of about 36 inches the subsoil is less compact, but there is more colloidal staining on the face of the aggregates, and an abundance of insect and worm burrowings but very little organic matter. The material is usually lighter brown, noncalcareous, and contains more gravel than the layer above. Small but easily crushed clods form when the material is disturbed.

Below 36 inches the substratum consists of loose stratified grayish-brown gravelly material, some of it lime-coated. At depths of 5 to

Orchards on Sorrento soils: *A*, Peach orchard. *B*, Almond orchard. Growing almonds is an important industry in the Newman area. Both peaches and almonds produce well on these soils.

A. Alfalfa on Sorrento gravelly loam. Baled hay is stacked at the extreme right background near the orchards in the distance. *B*. Baled alfalfa on heavy-textured Sorrento soils.

15 feet, in some places the gravel is weakly lime-cemented, forming a semihardpan, but usually this is too deep for the crops grown to be greatly affected.

This is a fairly good agricultural soil despite the numerous gravel particles that interfere somewhat with tillage and harvesting operations. Some of it is being put under irrigation, but owing to the slightly undulating microrelief the cost of leveling is high. The soil produces average yields of beans and would be fairly well suited to either alfalfa or orchards under irrigation. A total of 1,600 acres is mapped. Several rather large and representative bodies occur in the vicinity of Westley.

Positas gravelly clay loam.—The surface soil is rich-brown slightly acid noncalcareous gravelly clay loam that bakes hard on drying and breaks into hard angular clods when disturbed. The gravel is of small well-rounded quartz and hard metamorphosed sedimentary rocks. There are many roots but the organic-matter content is low.

At a depth of 4 to 15 inches the upper subsoil layer is reddish-brown slightly acid somewhat more compact gravelly clay loam or clay that breaks into angular clods with some colloidal stains. Grass roots are about as numerous as in the surface soil and the root channels are lined with a colloidal coating. There are not many insect holes in this layer. This layer rests abruptly on a brick-red mildly acid prismatic compact clay layer at a depth of 24 to 36 inches. This is the layer of greatest density and clay accumulation and contains less gravel than any other layer throughout the profile. The prisms are small and heavily coated with colloidal clay stains of slightly darker color than the interior of the aggregates, which are 3 or 4 inches long and about 2 inches in diameter. They are very hard when dry and tough and rubbery when moist. Roots are fewer in this layer and are mostly concentrated along the surfaces of the aggregates. To a depth of 40 to 60 inches the lower subsoil is reddish-brown or light reddish-brown noncalcareous gravelly clay of almost neutral reaction. It has some colloidal and dark manganese stains and only a few roots. The density and colloidal staining decrease, and the color becomes lighter with depth. Lime coating may occur on some of the gravel, and in some places a little lime is found in the normally noncalcareous, fine soil material.

The deeper material consists of stratified gravelly loam, clay loam, or clay of more friable consistence. This is normally noncalcareous, but lime coatings may occur on the gravel.

The native cover is grass, and the soil affords fair pasture for both sheep and cattle. A few areas are used for dry-farmed grain with only moderate success. The soil bakes hard and is easily puddled. Profitable yields are obtained in favorable seasons, but the normal rainfall is hardly sufficient to produce a paying crop even when summer fallowed. This soil occupies low stream terraces mainly along Orestimba Creek and has a gently rolling relief with a suggestion of hog-wallow microrelief. A total of 576 acres is mapped. Erosion is slight except for some sheet and gully erosion on the terrace slopes.

A few very small areas of lighter texture and more friable character near the mouths of Orestimba and Garzas Creeks are mapped with this type because of their small extent.

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Positas gravelly clay loam, hilly phase.—The hilly phase represents areas of the soil type having slopes of 20 to 30 percent. The soil profile is rather indefinite. Most of the areas occupy terrace rims and escarpments, and there is a great variation in depth of the soil material.

The surface soil is rich-brown noncalcareous gravelly clay loam, and the subsoil consists of compact gravelly clay material that may be massive or may exhibit prismatic structure in places. The underlying parent material is stratified gravelly terrace deposits. The entire soil profile is noncalcareous, but there may be some lime coating the gravel in the lower part and in the underlying material.

Erosion is moderate, with sheet erosion most active, although occasional gullies are present. A total of only 256 acres is mapped north of Orestimba Creek near where it enters the valley.

Positas gravelly clay loam, rolling phase.—The rolling phase represents areas of the soil type having slopes of 12 to 20 percent. The profile may be somewhat more variable than is typical of the series, especially on the steeper slopes. Despite the slope, erosion is usually slight.

The surface soil is rich-brown or reddish-brown noncalcareous gravelly clay loam. The subsoil, consisting of moderately compact structureless gravelly clay loam or gravelly clay rests abruptly on a very heavy brownish-red layer of compact clay having a prismatic structure that grades into a blocky structure in the deeper part. This rests upon a compact massive layer of gravelly clay. All these layers are noncalcareous, but there may be a few thin coatings of lime on some of the gravel in the lower part. The deeper parent material is stratified gravelly terrace deposits. The soil material is usually noncalcareous but the gravel is often coated with lime. This phase is used almost entirely for grazing. Only 192 acres is mapped just north of the point where Orestimba Creek enters the valley.

Positas gravelly clay loam, undulating phase.—This phase represents areas where the profile is very much like the normal throughout but the slopes are 5 to 12 percent. Erosion is slight, and occasional gullies are found. The surface soil is rich-brown noncalcareous gravelly clay loam without definite structure, friable when moist and hard when dry. The upper subsoil layer is reddish-brown somewhat compact gravelly clay loam or gravelly clay. Midway in the subsoil is a layer of heavy red clay with a prismatic structure, grading downward into small cubical aggregates, hard when dry and sticky when wet. The very few roots in this layer are concentrated along the cracks. The lower subsoil is massive compact gravelly clay, with many colloidal stains and some dark shiny manganese streaks. The soil material is usually noncalcareous, but some of the gravel may have a thin coating of lime. The parent material is stratified gravelly terrace deposits.

Though used mostly for pasture, this soil may at times be planted to dry-farmed grain. Pasture and grain yields are usually inferior to those obtained on Denverton clay (adobe) soil of the same general locality. In this area 384 acres are mapped, nearly all along the north side of Orestimba Creek where it enters the valley.

Rincon clay.—The surface soil to a depth of approximately 12 inches is grayish brown, noncalcareous, and normally without an injurious concentration of salts except in a few cases on the extreme lower edges of the alluvial fans. When wet the soil is sticky and on drying it forms a hard surface crust. If it is worked when too wet a plow sole is readily developed. The large blocks or clods that form when it is cultivated are fairly easily broken down to small aggregates under favorable conditions of moisture and cultivation. The soil is easily penetrated by roots and water and is retentive of moisture. There are many well-preserved worm and insect burrowings, but the organic-matter content is usually low.

To a depth of about 24 inches, the upper subsoil is brown, noncalcareous, and of a more pronounced blocky structure. Large vertical cracks separate it into moderately dense heavy-textured blocks. A large quantity of colloidal staining is on the surface of the soil aggregates. When the subsoil is wet it is very sticky but when thoroughly dried out it is hard and not easily crumbled. The lower subsoil is brown to yellowish brown and contains much segregated lime carbonate and some gypsum crystals in thin layers. An appreciable quantity of colloidal staining and a mottled appearance are due to the darker surface soil falling into cracks and streaking the lighter colored subsoil. This deeper material is not very easily penetrated by roots and contains only a few worm and insect burrows. Generally the soil is moist at this depth but is not so heavy-textured as the overlying layer and has no definite structure.

The substratum below 4 or 5 feet is composed of highly calcareous light-brown or yellowish-brown material, usually of lighter texture and more friable than the layer above.

This soil is extensively dry-farmed to grain, and large acreages are irrigated and planted to beans. These crops are fairly well suited to the soil, and the yields obtained are fair to good. Orchards do not do well on this type and alfalfa is planted with only moderate success, as good stands are a little more difficult to obtain and they die out a little sooner than on the Sorrento and Mocho soils. Yields, however, during the period of maximum production are fair to good. There is some alkali accumulation in a few bodies of this soil at the extreme lower edges of the alluvial fans bordering the valley trough. The salts somewhat inhibit plant growth and greatly limit use of the soil.

A total of 18,176 acres is mapped. Large areas occur in the extreme northern part and in the vicinity of Westley, Patterson, and Crows Landing. The land is smooth and very gently sloping.

In the earlier broader reconnaissance survey of the Lower San Joaquin Valley,[6] small areas of this soil were included with the soils recognized under the Antioch series, which it somewhat resembles.

Rincon clay loam.—The 10- to 15-inch surface soil is grayish brown and noncalcareous. It is readily penetrated by roots and water and is retentive of moisture but if plowed when too wet a plow sole is easily developed, and there is some tendency for a surface crust to form when the soil dries. No alkali salts are found in this soil, and the organic content is generally low.

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[6] See footnote 2, p. 3.

To a depth of about 24 inches the upper subsoil is brown, generally slightly heavier in texture than the surface soil, and noncalcareous. This layer is somewhat more compact and there is enough colloidal material to make the soil sticky when wet. Often the soil aggregates are faintly stained with colloids. The lower subsoil is also brown but contains appreciable quantities of segregated lime and some gypsum occurring as small crystals. This is usually of the same texture as the layer above, but it is less compact and has more colloidal staining. It is plastic when wet and when dry breaks into small irregular-shaped firm clods when disturbed. Roots and water penetrate to this depth readily, and moisture is well retained.

The substratum, or deeper parent material, generally occurs below depths of 4 or 5 feet and is light brown or yellowish brown and friable, but of as heavy texture as the soil above. It usually contains a large quantity of disseminated lime carbonate and some segregated lime and extends to an undetermined depth, in some places stratified with sandy material.

The soil is gently sloping, fair for agriculture, and extensively cultivated both as dry-farmed land and under irrigation. A variety of truck and field crops is grown with moderate success, beans and grain being the most important. The soil is not so well adapted to orchards, though fairly successful orchards have been grown after heavy applications of gypsum and manure and planting of fall cover crops, which are plowed under. The total of 2,752 acres occurs as isolated bodies throughout the area, with one large single body just southwest of Newman.

Riverwash.—This land type of loose poorly assorted sandy and gravelly material occupies overflow and intermittent stream channels. Its irregular eroded or wind-blown surface is low in organic matter and has unfavorable physical character. It supports little vegetation except occasional shrubs or grasses that may afford a little shade and pasture for livestock, and contains occasional pools and water holes that serve as watering places for some time after the winter rainy season. Otherwise it has no agricultural value. A total of 768 acres occurs mainly along Orestimba Creek. It may be overflowed during rainy periods but is exposed during the dry summer season.

Sacramento silty clay.—The surface soil is dark-gray, noncalcareous, and friable. Under cultivation it breaks into soft clods that are of low volume weight and easily reduced to a granular condition. The quantity of organic matter is fairly high. Numerous roots occur throughout, and some mottlings of rust-brown material are in the lower part.

This layer is underlain at a depth of 8 to 16 inches by a dull-gray intermittently calcareous silty clay, which is slightly more compact than the surface soil and the clods are a little more firm. Some colloidal stainings are on the soil aggregates and in the root and insect holes. The material in this layer is more highly mottled than the surface soil and becomes duller in color with increased depth. Some partly decomposed organic matter is often included in this and in the lower layers. Many roots occur throughout, but these decrease somewhat with depth. A few old root channels lined with iron stains and colloidal coatings extend vertically downward from the upper part of this layer to a considerable depth. The lower subsoil consists of

stratified intermittently calcareous micaceous sediments ranging in texture from sand to clay. These are dull gray to brownish gray and somewhat mottled with dull mottlings.

The water table is usually encountered at a depth of 3 to 6 feet below the surface. Drainage waters move freely through this soil, but because of the high water table it must be artificially drained, usually done by open ditches, before it can be successfully farmed. These drains often serve as means of irrigation by controlling the height of the water table.

The soil is normally very flat and somewhat cut-up by old sloughways. Some of the areas are overflowed in years of unusually high water, but most of them have been protected by levees and drained and are used for a variety of truck and field crops, but are unsuitable for orchards or vineyards. Celery, lettuce, and root vegetables do well, and grain and alfalfa also yield good crops, but alfalfa does not last more than 3 or 4 years under heavy cutting. The 3,904 acres are mapped in low basinlike areas on the flood plain of the San Joaquin River from Orestimba Creek nearly to the northern boundary of the area.

Small areas are included with the Hanford soils of the earlier reconnaissance survey[7] in which the soils were classified and mapped in much less detail.

Sorrento clay loam.—The grayish-brown surface soil of noncalcareous clay loam is generally cloddy when disturbed. It puddles easily and develops a plow sole if worked when too wet. The soil aggregates are firm when dry but soften up readily when moist. Organic matter is consistently low, and the type is usually free from injurious concentrations of salts. Roots and water penetrate this layer readily and it retains moisture well.

From a depth of about 25 inches and extending to more than 6 feet the subsoil is brown to light brown and contains lime both in the disseminated and mycelial form. There is no evidence of profile development normally, but occasionally the subsoil is somewhat more compact with a slight suggestion of vertical cracking, which property does not, however, prevent the free penetration of roots and water. In a few areas east of Patterson, the water table is fairly high because of excessive irrigation. This high water table restricts internal drainage and greatly reduces the agricultural use and value. If this condition is maintained for an extended length of time, the favorable physical properties of the soil will be endangered.

The soil is farmed extensively to a variety of truck and orchard crops (pl. 3), and large acreages are used for dry-farmed grain. Average yields are good to excellent, depending on the general farming practices employed. It is especially well suited to alfalfa, beans, and orchards, and if irrigation water is not available, dry-farmed barley or wheat do well when winter rains are favorable. This soil, occupying an area of 25,664 acres, occurs in large bodies on nearly level alluvial fans through the area.

Small areas were included with the soils of the Antioch series in the earlier reconnaissance mapping. The Sorrento series had not been recognized and established at the time of that survey.

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[7] See footnote 2, p. 3.

Sorrento fine sandy loam.—The surface soil is grayish brown, noncalcareous, and extends to an average depth of about 20 inches. It is very friable and has excellent physical properties, but if worked when too wet, there is a tendency toward development of plow sole. Small quantities of organic matter are present and the soil is free from concentrations of injurious salts.

The subsoil, consisting of stratified medium-textured sediments, is brown or light brown and extends to a depth of more than 6 feet. Lime is present in both a disseminated and an accumulated mycelial form. The entire profile is structureless and uniform. Roots and water penetrate easily, and moisture is retained fairly well in the deeper material.

This is one of the best soils for agriculture in California and will grow any crop that is climatically suited to the area. A variety of crops have been grown on it with excellent results. Because of its comparatively light texture, it is not so well adapted to dry-farm grain as some of the heavier textured soils that have a higher water-holding capacity. Orchard, field, and truck crops are grown extensively under irrigation, and if properly managed the soil will maintain its favorable physical properties for a long time. The total of 9,088 acres occurs in fairly large nearly level bodies in the vicinity of Crows Landing and Newman.

Sorrento gravelly loam.—The surface soil is grayish brown, noncalcareous, and gravelly to an average depth of about 25 inches and contains many small rounded particles of gravel. It is fairly friable but is easily puddled, and sometimes soft clods are formed when it is disturbed. The soil is well drained and contains no injurious accumulations of salt.

The permeable and friable subsoil is brown or light brown and extends to a depth of more than 5 feet. It is mildly calcareous, with both disseminated and mycelial forms of lime and is stratified with gravelly layers. Water and roots readily penetrate the subsoil and there is enough fine material in the soil mass to retain moisture fairly well.

The underlying substratum extends to an undetermined depth and is composed of brown stratified gravelly layers containing moderate quantities of lime carbonate.

Under irrigation the soil is suitable for nearly any crop that is climatically suited to the area (pl. 4). Dry-farmed crops may be grown, but heavier than normal winter rains are needed for good yields. The deep friable profile and the well-drained surface and subsoil are excellent for orchards. Gravel does not materially hinder tillage operations. The largest of the several bodies scattered throughout the area is about a mile northwest of Patterson. A total of 2,880 acres is mapped. The surface is nearly level or gently sloping.

Sorrento gravelly sandy loam.—The 15-inch surface soil is dominantly grayish brown, noncalcareous, coarse textured, very gravelly, and without consistent structure or evidence of profile development. It contains very little organic matter and is free from concentrations of injurious salts. The subsoil becomes coarser textured with depth, is brown in color, and contains moderate quantities of disseminated lime carbonate. The material extends to a depth of about 5 feet and in the lower part is somewhat stratified with coarse and fine sediments, below which coarse stratified quartzitic gravel and stone occur.

Most of the Sorrento soils are rated high for agriculture, but the gravelly types interfere to some extent with tillage operations and the gravelly subsoil is too porous to be highly retentive of moisture for plants. Lacking water for irrigation, the soil is dry-farmed to grain but only fair yields are obtained. Several gently sloping representative bodies occur close to Orestimba Creek near the base of the hills and west of Newman. A total of 2,944 acres is mapped.

Sorrento loam.—At an average depth of 20 inches, this type consists of a grayish-brown friable noncalcareous loam. This is often cloddy when disturbed, but the clods are easily broken to a granular tilth. There is, however, enough colloidal material to make it somewhat plastic when wet, and if worked when too wet a plow sole is readily formed. A small body northeast of Newman contains some alkali, but generally the type is free from concentrations of injurious salts.

The subsoil is brown or light brown and somewhat stratified, mainly with medium- and heavy-textured materials. Moderate quantities of lime carbonate, both in disseminated and mycelial forms, occur in the subsoil. This layer extends to depths of 5 or 6 feet and is usually friable, though in several widely separated localities the deeper material is somewhat more compact and the aggregates are faintly stained with colloids. Compaction does not seriously interfere with root and water penetration, and the soil is well drained.

The substratum, which extends to an undetermined depth, is generally light brown, highly calcareous, and composed of stratified sediments of variable-textured material containing some rounded particles of gravel.

Every type of agriculture suitable to the area is being practiced on this soil. Where good farming methods are employed, excellent yields are obtained. Occupying a total of 25,152 acres this soil occurs in many different localities on large nearly level alluvial fans.

Vallecitos stony clay loam.—The surface soil ranges in depth from 3 to 8 inches and is rich brown or grayish brown and noncalcareous. The presence of many angular rock fragments throughout the soil profile obscures the structure which is somewhat blocky, but the soil is rather friable and crumbles with moderate pressure to a granular condition. Many roots occur throughout this layer and under wooded or brushy cover there is a slight accumulation of leaves and partly decomposed organic matter on the surface. The reaction is slightly acid.

The subsoil ranges in thickness from 6 to 15 inches and is rich-brown noncalcareous stony clay loam or stony clay containing many rock fragments. This layer is somewhat more compact, and colloidal stains coat the surfaces of the irregular clods and root and worm cavities. The reaction is nearly the same as that of the surface soil. Drainage is free throughout the entire soil profile, and roots are numerous.

The soil is very shallow, and bedrock normally occurs at a depth of 10 to 18 inches. There are, however, a few spots where the soil material is as deep as 30 to 40 inches. These deeper areas have considerable development of subsoil, which is of stronger reddish brown color and is usually less stony. The bedrock is hard somewhat metamorphosed shale, shattered in the upper part and massive and hard below.

Some free lime carbonate is often found in the cracks of the rocks, although the bedrock proper is noncalcareous.

Despite the steep slopes, the vegetation and rock fragments throughout are sufficient to prevent serious erosion. The soil is absorptive and retentive of moisture and maintains a fairly good growth of trees and grasses with associated forage plants. Seepage from the moist soil usually provides sufficient water in springs and minor streams for use by livestock all year.

A total of 1,472 acres is mapped in mountainous areas of steep slopes and narrow ridge tops. The northern and eastern slopes are usually covered with trees and brush, with an undercover of grasses; whereas the southern and western slopes are more likely to be grass-covered. This soil is used entirely for range pasture. The vegetative cover offers too much protection for predatory animals to make these areas profitable for sheep.

Included on the map are areas in which 25 percent or more of the surface is covered by rock outcrop, the soil mantle is thinner, the vegetative cover is less vigorous, and the slopes are somewhat steeper than in the normal type.

Zamora clay (adobe).—This type, the only one of its series recognized in this area, is relatively low in organic-matter content and is noncalcareous throughout. It is fairly well drained despite heavy texture and slightly compact subsoil, and is free of alkali.

To an average depth of 16 inches the surface soil is dull grayish brown and slightly acid. It has a definite adobe structure when dry but is moderately friable, breaking into a granular tilth under favorable conditions of moisture. The soil, however, is very plastic when wet and will puddle readily if not properly handled. The structural cracks are not particularly wide but are pronounced and extend rather deeply into the profile. Many roots and worm burrowings occur in the surface layer.

The upper subsoil layer is a grayish-brown clay, slightly acid, and has a blocky structure to a depth of about 3 feet. This is somewhat more dense and the surface of the soil aggregates is faintly stained with colloids. The cracks extending from the surface are vertical and regular and facilitate the penetration of water through this layer. The lower subsoil, extending to a depth of about 6 feet, is light brown, of heavy texture, dense, and with dark colloidal stains on the face of the aggregates. Some of the profiles have a fairly well-defined cubical structure in this layer. Only a few roots are at the lower depths, although the material retains moisture through the dry summer season.

The underlying substratum is yellowish brown, generally lighter textured than the subsoil above, somewhat more friable, and may in places contain small quantities of segregated lime. Small quantities of shale fragments are scattered throughout the slightly stratified materials.

This soil is limited in its use for agriculture. Confined to gently sloping small narrow valleys and without available irrigation water, it is dry-farmed to grain. If irrigation were possible it could be used for a wider range of crops. Two relatively small but representative bodies a few miles southwest and northwest of Newman comprise the 192 acres mapped.

SOIL RATINGS

In table 4 most of the soil types and phases of the Newman area are rated on a percentage basis by means of the Storie soil index.[8] This is obtained by evaluating depth, texture, density of the surface soil and subsoil, acidity, alkali content, drainage conditions, slope, and other characteristics. The most favorable or ideal conditions are rated 100 percent.

In arriving at the relative index rating of soils three general factors are considered: (A) Character of the soil profile, (B) soil texture, and (C) miscellaneous conditions, including erosion, drainage, and acidity.

The A factor evaluates all characteristics of the soil profile except the texture of the surface layer. Characteristics considered under this factor are parent material, mode of formation, and degree of change in the soil material due to profile development or weathering agencies. The depth of the profile to bedrock or hardpan and the restriction of root penetration by development of compact or heavy clay layers are all of importance in determining the A factor.

The B factor is based on the texture of the surface soil independent of other profile characteristics, except those affected by texture, including consistence (hardness or softness) and porosity of the soil mass. All are important in tillage operations and moisture-holding capacity. Fine sandy loams, loams, and silt loams, and other soils of medium texture have a rating of 100 percent for this factor. These textures have the most favorable physical properties for general farming operations. Lighter textures are too loose, somewhat droughty, they may be blown by wind, and as a rule they are not so favorable. Consequently they are given lower ratings. Heavy-textured soils likewise have their disadvantages; they are more difficult to work, and moisture penetration is somewhat retarded.

In the C factor are included conditions characteristic of the soil that are not covered by factors A and B. Among these are drainage, erosion, alkalinity, acidity, low fertility, and steep relief. Where all of them are ideal this factor is rated 100 percent.

On the basis of the index rating, the soils are placed in six grades. Grade 1 soils (index rating between 80 and 100 percent) are considered to be of excellent quality and suitable for a wide range of crops, including deep-rooted permanent crops, as orchards, vineyards, and alfalfa. Grade 2 soils (index rating between 60 and 79 percent) are of good quality and suitable for most crops and for development under irrigation. Grade 3 soils (index rating between 40 and 59 percent) are suitable for many crops but are somewhat limited in their uses by extremes of texture, heavy-textured subsoils, alkalinity, erosion, or shallow bedrock. Some of the soils in this group may be excellent for specialized crops but do not have the wide range in suitability of grades 1 and 2. These soils are suitable for development under irrigation under some restrictions or for specialized crops. Grade 4 soils (index rating between 20 and 39 percent) are poor and have a narrow range in agricultural possibilities. Under certain conditions they can be improved by drainage, removal of alkali, or protection from flooding or erosion

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[8] STORIE, R. EARL. AN INDEX FOR RATING THE AGRICULTURAL VALUE OF SOILS. Calif. Agr. Expt. Sta. Bul. 556, 44 pp., illus 1933

so as to bring profitable returns. Grade 5 soils (index rating between 10 and 19 percent) are of very limited possibilities owing to shallowness, stoniness, steep slope, or other factors and are suitable mainly for pasture. Grade 6 soils (index rating less than 10 percent) are non-agricultural areas producing only meager pasture, and usually consist of rock-outcrop phases and areas of very high alkali content that are generally unsuitable for reclamation.

TABLE 4.—*Ratings of most of the soils of the Newman area, Calif.*

Soil types	Factors			Rating	Grade
	A	B	C		
				Percent	
Altamont clay (adobe)	60	70	100	42	3
Eroded phase	60	70	50	21	4
Eroded steep phase	60	70	20	9	6
Rolling phase	70	70	100	49	3
Steep phase	60	70	40	17	5
Altamont clay loam	50	85	100	43	3
Eroded phase	50	85	50	22	4
Eroded steep phase	50	85	20	9	6
Rolling phase	60	85	100	51	3
Steep phase	50	85	40	17	5
Ambrose clay (adobe)	75	60	100	45	3
Shallow phase (over Fresno soil material)—weak alkali	75	60	64	29	4
Shallow phase (over Fresno soil material)—moderate alkali	75	60	40	18	5
Shallow phase (over Fresno soil material) strong alkali	75	60	10	5	6
Ambrose clay loam	75	85	100	64	2
Columbia fine sandy loam	100	100	90	90	1
Columbia silty clay loam	100	90	80	72	2
Columbia soils, undifferentiated	-------	-------	-------	20-80	-------
Crow Hill clay	30	70	100	21	4
Crow Hill clay loam	25	85	100	21	4
Eroded phase	25	85	50	11	5
Rock-outcrop phase	20	85	50	9	6
Rolling phase	30	85	00	26	4
Denverton clay (adobe)	70	70	100	49	3
Eroded hilly phase	70	70	20	10	5
Hilly phase	70	70	50	25	4
Rolling phase	70	70	80	39	4
Denverton gravelly clay [1]					
Hilly phase	70	50	50	18	5
Rolling phase	70	50	90	32	4
Steep phase	70	50	40	14	5
Diablo clay (adobe)	50	70	100	35	4
Rolling phase	60	70	100	42	3
Dinuba fine sand	90	60	100	54	3
Dublin clay (adobe)	100	55	100	55	3
Esparto gravelly sandy loam	95	70	100	67	2
Gaviota fine sandy loam	25	100	100	25	4
Eroded phase	25	100	50	13	5
Eroded steep phase	25	100	20	5	6
Rock-outcrop phase	25	100	50	13	5
Rolling phase	30	100	100	30	4
Steep phase	25	100	40	10	5
Herdlyn loam	50	100	100	50	3
Kettleman clay loam	40	85	100	34	4
Eroded phase	40	85	50	17	5
Eroded steep phase	40	85	20	7	6
Rock-outcrop phase	25	85	50	10	5
Steep phase	40	85	40	14	5
Kettleman fine sandy loam	30	100	100	30	4
Eroded phase	35	100	50	18	5
Rock-outcrop phase	25	100	50	13	5
Rolling phase	35	100	100	35	4
Merced clay loam	80	85	60	41	3
Weak alkali	80	85	52	35	4
Moderate alkali	80	85	30	20	4
Mocho clay loam	100	85	100	85	1
Mocho fine sandy loam	100	100	100	100	1
Mocho gravelly loamy sand	100	50	50	25	4
Ohmer gravelly loam	60	55	100	33	4
Hilly phase	60	55	60	20	4
Undulating phase	60	55	90	30	4

[1] Normal phase not mapped.

TABLE 4.—*Ratings of most of the soils of the Newman area, Calif.*—Continued

Soil types	Factors			Rating	Grade
	A	B	C		
				Percent	
Orestimba clay loam—moderate alkali	90	85	30	23	5
Orestimba loam	90	100	60	54	3
Moderate alkali	90	100	30	27	4
Pleasanton gravelly clay loam	85	40	100	34	4
Pleasanton gravelly sandy loam	85	60	100	51	3
Positas gravelly clay loam	60	60	100	36	4
Hilly phase	60	60	50	18	4
Rolling phase	60	60	80	29	4
Undulating phase	60	60	90	32	4
Rincon clay	80	60	100	48	3
Strong alkali	80	60	20	9	6
Rincon clay loam	80	85	100	68	2
Sacramento silty clay	95	90	80	68	2
Slight alkali	95	90	68	58	3
Moderate alkali	95	90	40	34	3
Sorrento clay loam	100	85	100	85	1
Sorrento fine sandy loam	100	100	100	100	1
Sorrento gravelly loam	100	70	100	70	2
Sorrento gravelly sandy loam	100	65	100	65	2
Sorrento loam	100	100	100	100	1
Vallecitos stony clay loam	30	50	100	15	5
Zamora clay (adobe)	95	60	100	57	3

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and soil development acting on the parent soil material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief or lay of the land; and (5) the length of time the forces of development have acted on the material. The climate, and its influence on soil and plants, depends not only on temperature, rainfall, and humidity, but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

The semiarid climate under which the soils of the Newman area have accumulated is conducive to the development of Pedocals, but there are a few noncalcareous soils that can be definitely traced to the influence of parent material.

The mean annual rainfall in the valley part ranges from 9 to 12 inches, with approximately 80 percent of it occurring between November and April. The rainfall in the lower hills is approximately the same, but vegetation and soils indicate it to be greater in the higher hills, for which no rainfall records are available.

The soil profiles are for the most part only slightly to moderately well developed. Slight profile development is found in the deeper soils of residual origin. The strongest development is in the secondary soils, where for the most part streamways have been entrenched and no fresh alluvial material is being deposited on the surface.

The soils fall into six natural groups, based on physiographic position and degree of soil profile development. Group 1 represents hilly and mountainous uplands, where the soils have developed on residual

material from the underlying bedrock; Group 2 includes soils of undeveloped profiles formed on recent alluvial fans; Group 3 (young alluvial fans) consists of soils that have formed on the same or similar alluvial fans as those of Group 2 but have been in place long enough to have been slightly altered by environmental forces; Group 4 (older alluvial fans) represents an older and more advanced development in the soils of Group 3, in which structural development and accumulation of colloidal clay in the subsoils have become more pronounced; Group 5 comprises soils of the old alluvial terraces; and Group 6 (flood plains and basins) consists of alluvial soils deposited by the San Joaquin River and minor tributaries.

GROUP 1. HILLY AND MOUNTAINOUS UPLANDS

The soils of Group 1 are formed in place on sedimentary rocks most of which are sandstone and shale, with a little igneous material, but there is some conglomerate where rounded particles of gravel embedded in the sandstone and shale are quartzitic in character. The sandstone and shale formations differ considerably in kind and age.

Most of the rock strata are tilted toward the east, but the angle of dip is variable. The Coast Range Mountains in the locality have been considerably disturbed by uplifting, faulting, or other geologic agency. As most of the strata dip to the east, the western slopes are normally steeper, the soils are more shallow, rock outcrop is more frequent, vegetative cover is not so dense, and both gully and sheet erosion are more severe.

Of the six soil series represented in this group, four are Pedocals and two Pedalfers. The areal extent of the former greatly exceeds that of the latter.

The soils of the Gaviota, Altamont, Diablo, and Kettleman series represent the Pedocals. The first three are calcareous only in the subsoil, whereas the Kettleman is calcareous throughout the profile. The Gaviota, Altamont, and Diablo soils are darker colored than those of the Kettleman. The Gaviota and the Altamont are grayish brown or dull grayish brown, whereas the Diablo are dark gray to black and the Kettleman light gray or light brownish gray. The Altamont and Diablo soils are much alike in structure and physical properties, but differ principally in color. The Kettleman soils are more friable throughout and contain more lime in the subsoil. The position of the Vallecitos soil, which has been placed with the Pedalfers, is somewhat doubtful and possibly later data may place it with the Pedocals.

The Crow Hill and Vallecitos series are regarded as Pedalfers and have no lime in their profiles or in the parent material though they are formed under conditions of limited rainfall. These soils vary widely in color and other characteristics. The Crow Hill are gray or dull gray and the Vallecitos brown or rich brown and has a distinct reddish cast when wet. The former occupy narrow ridges extending roughly parallel to the major axis of the valley west of the terraces in the southern half of the area. The latter occurs in the southwestern corner of the area, which extends farther into the hills than any other part of this survey.

Some of the parent sedimentary rock materials giving rise to the soils of Group 1 have been much altered and metamorphosed. This

is the case especially in the rocks giving rise to the Vallecitos soil identified with the Franciscan geologic formation, which occupies the higher mountain ridges forming the backbone of the Mount Diablo range of the Coast Range. Parent materials of the Diablo soils are much more calcareous than those of the Altamont and the Gaviota, as is suggested by the dark color and the high content of lime in the subsoil. The Diablo soils are representative of the Rendzina soils of the Pacific Coast. Free lime in the Gaviota and the Altamont soils is not everywhere in evidence and in many places occurs only in the upper part of the parent rocks.

Parent materials of the Crow Hill soils appear to be related mineralogically to the Monterey shales, which give rise to the Santa Lucia soils of wide occurrence elsewhere in the Coast Range, but are of soft or very softly consolidated diatomaceous character, whereas the parent materials of the Santa Lucia are hard and flintlike or cherty. Why the dark-colored soils of these two series should have developed on noncalcareous materials under an environment giving rise to associated brown soils is not yet clear. The Vallecitos soil is covered with grass in places, but northern and eastern slopes usually support an open woodland growth of oaks and other trees, with undercover of grasses and herbaceous plants. The normally developed types are probably properly considered as zonal soils but the incompletely developed shallow stony areas represent the Lithosols and are azonal.

GAVIOTA SERIES

The soils of the Gaviota series are brown or dull brown and of medium to light texture. They are of moderate to low organic-matter content, neutral to slightly acid in reaction, developed in place on sandstone bedrock with some associated shale material, and dominantly shallow and of friable character.

The subsoil has little profile development and is but slightly heavier in texture or more compact than the surface soil. It is moderately calcareous, the lime being mainly disseminated but some segregated mottlings and seams may occur, and scattered fragments of the parent sandstone occurring in the soil material are lime coated. The underlying parent bedrock is soft and partly disintegrated in the upper part, which contains some roots and segregated lime in cracks. The relief is hilly, with rolling, steep, and eroded areas.

Native vegetation consists of grasses associated with bur-clover, alfileria, and other herbaceous plants. These make good growth during winter and spring, but dry up during summer droughts. The soils are used mainly for grazing sheep. Dry-farmed grains are grown to a limited extent, but owing to low rainfall and shallow soil material the yields are low.

ALTAMONT SERIES

The Altamont series consists of Pedocals with youthful or immature profiles. They are developed in place on sedimentary rocks, mostly sandstone and shale with very little conglomerate. The rounded gravel particles embedded in the conglomerate are hard sandstone and quartzitic rocks with occasionally some inclusion of igneous rock. It is doubtful whether there has been sufficient weathering of the gravel to contribute any material part of the soil mantle.

This series occurs in hilly areas at elevations of 200 to 1,600 feet. The eastern hill slopes are more gentle and the soils deeper than the western. The rocks dip to the east, and rock outcrops are more frequent on the western slopes. The soils of this series occur in close association with most of the other primary soils and some of the older soils of the terraces. The clay (adobe) type is much like the clay (adobe) of the Diablo series, except that the color of the latter is darker.

Though related to the Kettleman series, the Altamont soils differ in having a darker color and being noncalcareous in the surface, whereas the Kettleman soils are calcareous throughout and are much more highly calcareous in the subsoil.

Erosion is only slight on the clay (adobe) type, but is more severe on the lighter textured clay loam. Sheet erosion with some gullying occurs on the eastern slopes, and on the steeper western slopes where rock outcrop is more frequent, soils are more shallow, vegetation is less dense, and both sheet and gully erosion are more severe, with some development of pot holes. Pot holes usually occur where the rock strata underneath have been shattered or crumbled by folding or faulting of the rocks. Under these conditions the substrata are more highly erosive than the soil mantle and considerable damage results. All the erosion processes are increased by overgrazing, mainly by sheep. In many areas the vegetative cover is almost entirely eaten, leaving no protective cover for the rainy season.

Surface and internal drainage are good. In a few small areas underground waters form small seepage spots surrounded by darker colored soils that are usually somewhat boggy for some time after the soils surrounding have dried out. Such spots are likely to contain some alkali, and salts often occur along the drainage channels. These are too small to be differentiated on the map, but are characteristic of this series.

The surface soil is dull grayish brown and noncalcareous with a distinct brown color when viewed across a bare field. Though normally friable, it bakes hard if puddled or packed by pasturing when wet. The lighter textures have no pronounced structure but break into irregular-shaped clods. When dry the clay (adobe) type is permeated by secondary cracks that reduce the larger blocks to small clods and fragments. The surface soil material sloughs off and falls down the large cracks, giving a mottled color to the subsoil, which is normally of somewhat lighter color than the surface. Some shale or sandstone fragments occur throughout the surface, some of which are coated with lime. The quantity of these rock fragments increases with depth, and in the subsoil they are almost always coated with lime. The content of organic matter in both surface soil and subsoil is low, and the reaction is about neutral.

The subsoil is brown, grayish-brown, or light-brown irregular calcareous material, usually of slightly heavier texture than the surface. A little colloidal staining is usually present on the surface of the soil aggregates and along root and insect holes. Roots are numerous in the subsoil but less abundant than in the surface. Lime occurs mainly in disseminated form, but in the lower part of the subsoil some mycelial lime and even a little nodular lime may occur. Some crystalline gypsum may also be found in the lower subsoil and in the cracks

of the underlying bedrock. The structure in the subsoil, where the soil has sufficient depth, is usually more definite than in the surface soil.

The upper part of the parent material consists of soft crumbling bedrock, usually with considerable lime and often some gypsum in the seams and cracks. The deeper unweathered bedrock is normally noncalcareous, but in some places seams of lime are present.

The native vegetation is grasses and herbs with a few shrubs in the area of rock outcrop and some scattered oak trees in a few localities. Practically all these soils are used as range pasture.

DIABLO SERIES

The soils of the Diablo series are developed on shale and highly argillaceous sandstone and are youthful to immature in profile development. The parent material gives rise to heavy-textured soils. The shale and argillaceous sandstone are calcareous, soft, and broken down or disintegrated to considerable depths. The relief is hilly to mountainous, but in this area the soil does not extend to the higher elevations. The slopes are broad and smooth and the tops of the ridges rounded. The soils are high in colloids and when dry the mass shrinks, cracks open, and develops an open blocky and fragmental structure that absorbs most of the rain, causing a minimum of runoff and erosion. There is very little gullying, and sheet erosion is slight. Shrinkage cracks extend deep into the subsoil, sometimes even to the parent material, and, although the soil texture is dominantly heavy, internal drainage is not greatly restricted.

Diablo soils are not extensive. They occur under somewhat lower rainfall than where developed in other areas surveyed. These soils are associated with the Gaviota, Altamont, and Crow Hill series, and with some of the old terrace soils.

Water seeping from these soils and entering the drainageways sometimes contains considerable soluble salts, as indicated by white coatings deposited along the banks of the streamways and the occasional appearance of saltgrass or other alkali-tolerant plants. The localized areas of salt accumulation are too small to be differentiated on the map.

The surface soil is dark-gray or black noncalcareous material of adobe structure that when dry cracks into small rough cubes or irregular aggregates 1 or 2 inches in diameter, hard when dry but sticky when wet. Reaction is nearly neutral. Small rock fragments occur throughout the soil, a few of which are calcareous, and the quantity of organic matter is moderate.

The subsoil is dark gray to almost black in some places, becoming lighter in color with depth, and the lower part is calcareous. A little development in profile is usually obvious in the subsoil, the soil aggregates being somewhat harder, often with some colloidal staining on their surface. The quantity of rock fragments increases with depth, and those in the lower part are usually coated with lime. Dark-colored surface soil material falling into the cracks often gives the lower subsoil a rather mottled appearance. Many grass roots are found throughout this layer and though not so numerous as in the surface soil they are well distributed, not concentrated along the

cracks. This layer grades into a transition zone a few inches thick in which some soil material is mingled with the fragmental bedrock. This layer is calcareous, with a little segregated lime in seams and on the surface of the numerous rock fragments. The deeper bedrock is noncalcareous but very soft and somewhat crumbled.

Native vegetation consists of a relatively heavy cover of grasses and associated herbaceous plants. All the soil in this area is used as pasture for sheep, and although it is usually overgrazed, erosion is slight.

KETTLEMAN SERIES

The soils of the Kettleman series have youthful or weakly developed profiles, developed on sedimentary rocks, mainly shale and conglomerate. The conglomerate consists principally of rounded hard sandstone and quartzitic gravel embedded in shale. These hard rocks are so resistant that it is probable that weathering has not been sufficient for them to contribute very much to the soil mantle. Some fine-grained sandstone makes up a small part of the parent material.

These soils occupy hilly to mountainous areas, mainly along the western slope of the first ridge bordering the valley in the northern half of the area, with some areas of very steep slopes that have some rock outcrop. They are subject to rather severe erosion in places.

There has been much folding and uplifting, and most of the rock strata dip at variable angles to the east, exposing a cross-section of bedrock strata along the western slopes, much of which is broken and shattered. On such exposures soils are shallow, vegetation sparse, erosion very severe, and pot holes and gullies frequent. All forms of erosion are greatly increased by overgrazing of sheep.

External and internal drainage are usually excellent, but in a few seepage areas and narrow strips along drainageways some alkali has accumulated. Seepage water late in spring coming from these soils as well as from those of the Altamont and Diablo series contains appreciable quantities of salts, which have precipitated and accumulated along the stream banks.

The surface soil is light yellowish gray or light yellowish brown, calcareous, and of friable soft cloddy character when disturbed. The soil seldom puddles and maintains a friable structure under both wet and dry conditions. Some small rounded gravel particles, many of which are coated with lime, may occur on the surface and throughout the soil profile. The subsoil is of similar color, calcareous, and of slightly heavier texture but very friable, the soft clods breaking down readily. There is usually some mycelial lime, with some soft nodular lime, and in places crystalline gypsum. Grass roots are numerous throughout this layer but less so than in the layer above. The quantity of organic matter in both the surface soil and the subsoil is very low. The upper part of the bedrock is badly shattered, and some soil material and considerable segregated lime and gypsum with a few roots occur in the cracks. Except in a few areas the interior of the rock fragments is noncalcareous.

The native vegetation is grasses and associated herbaceous plants with a few shrubs on the areas of rock outcrops. All these soils are used as sheep pasture. For the most part they are badly overgrazed. The carrying capacity of the pasture depends almost entirely on the depth and management of the soil.

CROW HILL SERIES

The soils of the Crow Hill series, normally very shallow, are of weakly developed profile and derived in place from diatomaceous shale. They occupy hilly relief with gentle to moderately steep slopes and occur in narrow ridges running roughly parallel to the major axis of the valley. These soils are subject to considerable sheet erosion and some gullying, and the lighter colored subsoil is conspicuous where thus exposed. Drainage is free in both the surface soil and subsoil and the seepage waters show no evidence of containing much soluble mineral material.

The surface soil is dull grayish brown, dull gray, or dull brownish gray, with light-colored eroded spots. The upper inch or two is dark because of slight accumulations of organic matter, although the total quantity is very low. The volume weight of the soil is extremely low and it has many very fine pores. The grass roots are far more numerous in the surface soil than in the subsoil.

The subsoil is medium to slightly acid, dull colored, with some colloidal staining, but somewhat lighter than the surface soil, and is slightly more compact. This material breaks into angular clods having slightly higher volume weight than the surface soil, but containing many fine pores. Some shale fragments occur throughout the profile, the number increasing with depth.

The parent material consists of soft light-gray or almost white diatomaceous shale that is porous and has a low volume weight. The upper part of the bedrock is broken and somewhat mixed with soil material.

The vegetative cover of grasses and associated herbaceous plants is used mainly for pasture. Some dry-farmed grain is raised at irregular intervals. Fields are roughly plowed, and grain is sown with very little other tillage operations. Such practices are based on chance of a favorable rainfall season. If the season is not favorable, the increase in pasture may almost repay the cost of planting.

VALLECITOS SERIES

The soil of the Vallecitos series has immature profile development on a complex association of sedimentary and metamorphic rocks with some igneous intrusions, mostly basic. Accordingly to Anderson and Pack [9] these rocks are the Franciscan formation, probably of Jurassic age, the oldest formation in the Diablo Range.

The soil occupies mountainous areas with very steep slopes and narrow ridge tops. The many angular rock fragments on the surface and throughout the profile, together with the grass and tree roots, protect the soil, so that despite the steep slopes, there is very little erosion.

Drainage is excellent, but seepage waters from a number of springs keep the soil fairly moist locally. There is more protective cover on this soil, and seepage into the creeks and drainageways continues for longer periods during a dry summer than on the other residual soils of the area. The soil is entirely free from injurious accumulations of salts.

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[9] ANDERSON, R., and PACK, R. W. GEOLOGY AND OIL RESOURCES OF THE WEST BORDER OF THE SAN JOAQUIN VALLEY NORTH OF COALINGA, CALIFORNIA. U. S. Geol. Survey Bul. 603, 220 pp., illus. 1915.

The surface soil is grayish brown or rich brown, often with a distinct reddish cast. The soil material is friable, and structural development is masked by admixture of angular rock fragments. For the most part these rocks are hard metamorphosed shale with some chert and quartz fragments. Many plant roots occur throughout the entire profile, but they are most numerous near the surface. The reaction is slightly acid. There is a slight accumulation of organic matter in wooded areas, and a moderate quantity in the upper 2 or 3 inches of grass covered areas.

The subsoil, containing many angular rock fragments, is slightly lighter and richer brown than the surface, and there is some development of a cloddy structure and some colloidal staining. This layer is slightly more compact than the surface soil, but is still moderately friable, and the reaction is the same or only slightly higher. Normally the entire profile is less than 2 feet deep. In a few places, however, where it reaches 3½ feet there is more development of the subsoil. These areas usually occur on north slopes in localities where some material has worked down and accumulated from above. In such places there may be a small quantity of lime in the upper part of the bedrock, which is badly shattered, and some soil material has been worked down into the cracks into which a few roots have found their way, especially in wooded areas. The rocks themselves are hard and angular and do not crumble readily.

The northern and eastern slopes are covered with trees and brush, with a grass undercover, whereas the southern and some of the western slopes are covered with grass and occasionally some shrubs. Rock outcrops occur throughout.

Because coyotes, wildcats, mountain lions, and other predatory animals cause too great loss among sheep, these soils are used mainly as range pasture for cattle. These areas are not so badly overgrazed by cattle as those pastured to sheep. Water for livestock is nearly always available, which allows pasture the year around. Because of the steep slopes and stony character, this soil will never become important agriculturally, but with proper range management practices it should continue to afford good pasture.

A representative area of Vallecitos soil adjacent to the Newman area has the following profile, in which the surface soil is very slightly acid and the subsoil and parent material are mildly alkaline.

A 0 to 6 inches, light-brown noncalcareous friable stony clay loam. When disturbed it breaks into irregular or angular aggregates, containing many fine rootlets and worm and insect channels. The aggregates are reduced to a granular mass with slight pressure. Numerous angular fragments of parent rock occur on the surface and throughout the soil mass. A very thin accumulation of oak leaves and grass fragments is present on the surface, but there is no real development of organic surface litter.

B. 6 to 14 inches, light-brown noncalcareous heavy clay loam. There is no well defined structure in place, but the material breaks out into blocks of irregular shape when disturbed. These are somewhat more dense or firm than the surface soil aggregates, roots are somewhat less numerous, and insect and worm borings and channels are less frequent. Some colloidal stains occur on surfaces of the aggregates and in the larger pores and cavities.

C 14 to 21 inches, very light-brown shattered or partly disintegrated bedrock. Some soil material and a few of the deeper roots have worked down into the cracks in the rocks. Bedrock becomes harder and more massive with increase in depth.

GROUP 2. RECENT ALLUVIAL FANS

The soils of Group 2 include the Mocho and Sorrento series, which consist of recent alluvial deposits derived from materials of sandstone and shale origin and which may or may not contain lime in the profile. The soil material has been transported from the uplands by minor streams and deposited in the valleys, forming large gently sloping alluvial fans. The Mocho soils are calcareous in both surface and subsoil, and the Sorrento are calcareous only in the subsoil. Both are azonal and definitely Pedocals.

The streams that have deposited the soils of the recent alluvial fans maintain stream flow during only the rainy season. They emerge from small canyons and stream valleys of the uplands and lose themselves on individual or confluent alluvial fans as they enter the main valley. Because they are of recent accumulation, soil-forming processes have not been in operation long enough to develop a soil profile, and the soil section is characterized by stratified parent geologic materials rather than by developed soil horizons. Owing to their youthful undeveloped character, these soils reflect in mineralogical and chemical character the parent materials from which derived. They are open and permeable, and the subsoil is frequently of lighter texture and more open than the surface soil. Where clay materials occur in the subsoil they are of stratified nature and not of development or clay migration nature. The smaller individual alluvial fans may have slopes of 10 percent or more, but the larger confluent fans have longer slopes, ranging from 4 or 5 to as little as 1 percent.

MOCHO SERIES

The soils of the Mocho series, composed of outwash from soil materials derived from sandstone and shale, are on broad fans of low gradient with associated narrow flood plains bordering the minor stream channels. The profile is recent, with no evidence of illuviation or other development, but usually includes stratified layers a few inches thick and of variable texture. For the most part these soils are still subject to occasional flooding and are built up by alluvial accumulations.

The light grayish-brown or light brownish-gray surface soil contains disseminated lime in variable quantities and is easily penetrated by roots and water. Soft clods, readily broken into a granular tilth, are formed when the heavier textured soils are plowed. A weak crust tends to form on the surface after heavy rains or surface irrigation.

The light-brown or light yellowish-brown subsoil is usually highly stratified and extends to depths in excess of 6 feet. The thin layers of laminated silty material that frequently occur in this horizon are usually slightly darker colored and represent old surface soils that have been covered by subsequent depositions. Lime in the upper subsoil is disseminated and small quantities of mycelial lime occur at lower depths. All soil types have loose friable subsoils with numerous root holes and insect burrows fairly well preserved. The soils have excellent drainage and permit ready penetration of roots and moisture.

Prior to the comparatively recent cultivation of these soils, the native vegetation was dominantly grasses and associated herbs. Yearly rainfall averages slightly more than 10 inches, most of which is absorbed by the soil. This deep and permeable alluvial soil with

an average slope of less than 2 percent is not eroded and is free from alkali.

Although this series was first recognized in 1910 in the Livermore area,[10] it has not been extensively mapped in California. These soils are generally considered First-class soils except for a few isolated spots where gravelly subsoils occur at shallow depths.

SORRENTO SERIES

The soils of the Sorrento series occupy large parts of the broad gently sloping alluvial fans extending into the main valley from the many canyons and minor tributary stream valleys. They are formed from the outwash of soil material having its source in sandstone and shale and deposited by minor streams that have played back and forth across the surfaces of the fans. Intermittent deposition of extremely variable quantities of parent material has given rise to a variation in stage of profile development ranging from strictly recent to early youthful. In some areas there is no evidence of profile development, while in others a slight modification is evidenced by development of structural units and colloidal staining on the soil aggregates. These soils, however, are still receiving small increments of material at intervals and are undergoing a process of aggradation, or building up, rather than erosion.

The light grayish-brown surface soil is noncalcareous. There is a tendency for a hard surface crust to form in the heavier textured types, but this readily breaks down when cultivated. Plow soles are easily developed and greatly inhibit root and water penetration. With proper management, however, these soils will retain their excellent physical properties.

The brown stratified subsoil bears no consistent textural relation to the surface soil. This horizon is generally well permeated by roots and worms and in places is slightly more compact, and occasionally slight colloidal stains line the cavities. Lime occurs in both disseminated and mycelial forms.

The light-brown underlying substratum is more calcareous than the upper horizons. It is composed of stratified deposits of variable texture ranging from gravel to clay, with the medium texture prevailing. Tree roots easily penetrate to this depth and moisture is fairly well retained.

Most of the Sorrento soils in this area are excellent, though a few small very gravelly areas are of lower value. The soils are generally well drained and readily absorb the low annual rainfall. They are practically free from salts and are consistently low in organic matter. Grasses dominated the native vegetation before the soils were cultivated.

A representative profile of Sorrento silty clay loam as observed in the survey of an adjoining area is as follows:

0 to 17 inches, grayish-brown noncalcareous silty clay loam of soft cloddy character under cultivation, very friable, the aggregates reduced by slight pressure to smooth granular tilth. Although of heavy texture the soil particles are flocculated and impart the physical character of a much lighter textured soil.

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[10] WESTOVER, H. L., and VAN DUYNE, C. SOIL SURVEY OF THE LIVERMORE AREA, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. (1910) Rpt. 12: 1657–1716, illus. 1912.

17 to 35 inches, light-brown calcareous silty clay loam or silty clay breaking into soft cloddy friable aggregates when disturbed Numerous roots and worm channels enter this material, which is slightly stained with darker colored colloidal materials. The lime is mostly disseminated but a few threads and veins occur in the lower part of the layer.
35 to 56 inches, light yellowish-brown calcareous very friable silty clay loam without definite structure in place but breaking into soft aggregates when removed. Fine mycelial like threads of accumulated lime penetrate the material.
56 to 75 inches, light yellowish-brown silty clay loam that is loose, permeable, and somewhat stratified.

GROUP 3. YOUNG ALLUVIAL FANS

The soils of Group 3 include the Zamora and the Dublin series, both of which are represented by single types of heavy clay texture and adobe structure. They have slight to youthful profile development and are transitional between the group of unmodified recent alluvial fans and that of the older alluvial fans. Of these the Zamora is the more closely identified with the soils of the older alluvial fans, whereas the Dublin, which occurs in small scattered areas, is more closely identified with those of the recent alluvial fans. The Dublin soil is noncalcareous. The soil material of the Zamora does not effervesce, but gravel in the underlying material is in places coated with lime. The soil is probably best regarded as a noncalcareous Pedocal.

DUBLIN SERIES

The noncalcareous soil of the Dublin series is formed from transported material derived from sandstone and shale. As occurring in this area the soil seems to have reached the stage of feebly developed profile. This soil occupies small alluvial fans of low gradient at the base of ridges and terraces associated with soils of the Crow Hill, Diablo, and Denverton series. Deposition of fresh alluvial material by occasional surface drainage waters tends to building up rather than erosion. Surface drainage is good but internal drainage is somewhat restricted by the heavy texture. Native vegetation is dominated by grasses. The soil is free from accumulations of injurious soluble salts.

The surface soil is dark gray or black, heavy textured, slightly acid, and contains a fairly large quantity of organic matter. When dry, large cracks separate the heavy-textured soil into rather regular blocks that develop secondary shrinkage cracks, which eventually break the soil down to a mass of small granular or angular fragments readily worked to a favorable tilth under cultivation. Many fine roots and a few light-colored shale fragments occur in this horizon. Although this soil has a fairly high organic content, it is plastic when wet and becomes puddled and difficult to till under unfavorable conditions of moisture and cultivation.

The upper subsoil is slightly darker than the surface soil and considerably more dense. Some indication of profile development is present, but subsoil density is due mainly to the heavy clay texture. Surface cracks extend downward through this layer, and the soil breaks into large irregular-shaped blocks. A few small roots may penetrate the blocks and are not confined to the cracks. Small light-colored shale fragments are present, and the material has less organic matter and is neutral in reaction. The dull grayish-brown lower subsoil is slightly alkaline, has no definite structure, and breaks into

a crumbly and moderately friable material. Some of the surface cracks into which the darker surface soil has fallen extend into this horizon, giving it a mottled appearance. Small light-colored shale fragments are less frequent, and a perceptible quantity of moisture is held at this depth.

The yellowish-brown substratum is friable and without definite structure, but contains small quantities of crystallized gypsum. The shale fragments have almost disappeared, the moisture content is fairly high, and the reaction is alkaline.

ZAMORA SERIES

The noncalcareous soil of the Zamora series is derived from transported material originally of sandstone and shale origin. This material has been eroded mainly from the Gaviota and Altamont soils and deposited by minor streams. The profile is youthful and much like that of Esparto, except that the surface soil is darker. It is well drained and subject to slight deposition of fresh alluvial material in some places rather than to erosion.

The dull grayish-brown surface soil is generally friable and porous. The heavy-textured types are plastic when wet and there is a strong tendency to form a plow sole if not handled properly. An abundance of roots is usually present in this horizon, and the soil is slightly acid.

The grayish-brown upper subsoil is somewhat heavier textured than the surface soil but without a definite structure, contains fewer grass roots, and is less acid. It is somewhat more dense in the deeper part. A slight suggestion of small blocky or cubical structure is developed by the cracks that form when the soil dries out. These aggregates are often coated on the outside with a thin colloidal stain that is distinctly darker than the inner part. The lower subsoil is generally lighter brown and neutral in reaction.

The underlying substratum is yellowish brown, lighter in texture than the soil above, and somewhat friable. Small quantities of shale fragments are frequently intermingled with the more or less stratified alluvial sediments. Some of these are coated with lime.

In the main the Zamora soil is good agriculturally. In this area there is no irrigation water available, and the type here is used mainly for grain or pasture.

GROUP 4. OLDER ALLUVIAL FANS

The five members of group 4—Esparto, Pleasanton, Ambrose, Rincon, and Herdlyn—occupy various positions on the broad alluvial fans. The soils are derived from transported material of sandstone and shale origin. Although some types may occasionally receive small increments of soil material, all have occupied their present positions long enough to have developed well-defined profile characteristics. The soils of the Esparto and Pleasanton series are probably best regarded as noncalcareous Pedocals, for although the soil materials do not contain lime, the subsoil and substratum gravel particles are often coated with it. The Ambrose, Rincon, and Herdlyn series also are Pedocals.

The profiles of the various soils of this group are distinctly different and there is a noticeable variation in the degree of their development.

The Esparto soil generally occupies the upper parts of the fans and is the youngest member of the group. The Pleasanton soils, which are usually gravelly and slightly more developed than the Esparto, occupy lower fan slopes. The Ambrose and Rincon are next in stage of development, the Ambrose a trifle more strongly developed. These soils, especially the Rincon, occupy a wide range of positions, but the largest bodies are near the center of the fans. The Herdlyn soil is the most strongly developed of the group, but occurs in only a few small bodies.

Streamways traversing these soils are entrenched below the general level, and the soils rarely receive any increment of fresh alluvial materials. The typical microrelief is smooth, but some of the older or more strongly developed soils have in places a hog-wallow configuration with the low mounds and intervening flat or shallow basinlike areas characteristic of the older valley plains and terraces. The surface soils are permeable, but internal drainage takes place more slowly in the more compact and heavier textured subsoils, and the soils are of good moisture-holding capacity. Surface drainage is adequate, and the underground water table lies well below the surface.

The Ambrose soils have a somewhat more strongly developed profile than the Rincon. The Herdlyn soil is of flatter relief, has developed a more dense subsoil, and is approaching the Planosol stage.

ESPARTO SERIES

The soil of the Esparto series is formed from transported material derived originally from sandstone, shale, and conglomerate. This soil is well drained and youthful and occupies the uppermost part of the alluvial fans. Most of the outwash material from which it was formed has come from the soils of the Altamont and Gaviota series. The native vegetation was grasses and herbaceous plants, and the soil has developed under an annual rainfall of less than 11 inches. It is free from alkali and is slightly acid in the surface. In this area it is believed to be undergoing deposition of soil material from time to time and to be in the process of aggradation or building rather than erosion.

The surface soil is grayish brown when dry, friable, and slightly acid. When viewed across a cultivated field it is a rich brown, especially when wet. Generally enough colloidal matter is present in the surface horizon to make the soil plastic when wet, and if not handled properly a plow sole is readily formed. The soil is also easily puddled and tends to bake and develop a hard surface crust when dry. Under cultivation it breaks into firm but porous clods and the crust disappears.

The upper subsoil layer is brown and less acid than the surface soil and contains many worm holes and roots. It is also slightly more compact and has some colloidal staining. The soil mass breaks into small irregular-shaped and easily crumbled aggregates. The lower part is almost neutral in reaction and the color changes to a light brown. This layer is more compact, and the soil aggregates are stained with darker colloidal coatings. Roots easily penetrate to this depth, but worm and insect burrowings are less numerous.

The underlying substratum is light grayish brown and neutral in reaction. It is generally composed of loose stratified gravelly or

sandy layers with a spotted lime coating on some of the gravel particles.

PLEASANTON SERIES

The soils of the Pleasanton series, derived from conglomerate and other sedimentary rocks, are noncalcareous. They occupy a position well towards the upper parts of the fans and are generally gravelly throughout the profile. The small to medium-sized gravel is mainly of hard quartzitic rock. The soils are underlain by lime-coated gravel and cobbles and in some places by a lime-cemented layer. The profile is youthful to immature and has developed under conditions of good drainage and an annual rainfall of less than 11 inches. The surface soil and upper subsoil are neutral in reaction, consistently low in organic matter, and apparently with no concentration of injurious salts. Erosion is slight, mainly because of the gently sloping relief and relatively low annual rainfall. These soils are only fairly well suited to agriculture because of the quantity of gravel.

The surface soil is dull brown and moderately friable when moist but forms a hard surface crust when dry. This layer is shallow and contains many rounded particles of gravel of an average diameter of less than 2 inches.

The upper subsoil is moderately compact and slightly restricts the downward penetration of water and roots. Generally this layer is brown and the gravel is firmly embedded in the soil material. While generally massive in places, the soil gives a slight suggestion of prismatic structure when disturbed. Some colloidal staining is on the soil aggregates, and the root and worm holes penetrating this layer are well preserved. The lower subsoil is less compact but is more intensely stained with colloids and contains more gravel. Generally the soil material is light brown, and worm and insect burrowings are more noticeable. Small but easily crushed clods form when the material is disturbed.

The substratum is composed of moderately friable sediments with a high content of gravel. Here the gravel is more open and more freely permeable and without colloidal staining. The material is generally grayish brown or light grayish brown and slightly alkaline. The deeper gravel is often coated with lime and sometimes softly cemented by lime into thin seams.

AMBROSE SERIES

The soils of the Ambrose series, developed on transported material originally derived from sandstone and shale, may occur anywhere on the smooth gently sloping fans, but are generally near the lower edge close to the valley trough. The soils have developed under low rainfall and good drainage with a native cover of grasses. Accumulations of salts occur in areas on the lower part of the fans. On the upper part of the fans, where the gradient is more than 3 percent, a few small bodies appear to be eroding slightly. In the main, however, these soils are neither eroding nor receiving evident depositions of soil material. Organic-matter content is generally low, and the reaction is neutral to slightly alkaline.

The dark brownish-gray or dark grayish-brown surface soil is noncalcareous and moderately friable, is readily penetrated by roots and water, and is fairly retentive of moisture.

The dark grayish-brown upper subsoil is intermittently calcareous and is moderately compact and heavier textured than the surface soil, with a slight suggestion of small blocky or cubical structure when dry. Drainage is somewhat restricted, and the soil is dense and sticky when wet. Considerable dark colloidal staining is present on the face of many of the soil aggregates. The grayish-brown lower subsoil is lighter and has considerable segregated lime in mycelial and soft nodular form. This horizon is moderately compact and generally massive without definite structure. Lime tends to modify the compactness of this layer and facilitates root and water penetration.

The underlying substratum is light brown, contains large quantities of disseminated lime, and is porous and friable. No colloidal staining and only a few root and insect holes occur at this depth.

The Ambrose soils are somewhat like the Rincon but of slightly more strongly developed profile and darker color. Fairly good agricultural soils in the main, they are suitable for dry-farmed grain, beans, and flax, but less desirable for alfalfa.

RINCON SERIES

The soils of the Rincon series are derived mainly from transported material eroded from the Altamont and Kettleman soils and deposited by minor streams on broad gently sloping alluvial fans. The profile is in the immature stage of development, and the subsoil contains a fairly large quantity of segregated lime. The soils occupy a wide range of positions on the fans and may or may not be subject to slight erosion. They are consistently low in organic matter, and apparently without concentrations of injurious salts. The original native cover of grasses developed under conditions of low rainfall and good drainage.

The surface soil is generally grayish brown when dry and becomes richer brown when wet. It is noncalcareous and friable with no pronounced structure except in the heavy-textured clay type, is readily penetrated by roots and water, and is retentive of moisture. A plow sole is easily formed if the soils are worked when too moist. There is also some tendency for a firm crust to form on the surface when dry, which breaks into porous fragments under cultivation. Worm and insect burrowings, aiding water penetration, are numerous.

The upper subsoil is brown, noncalcareous, and generally heavier textured than the surface soil, somewhat more compact, very sticky when wet, and dries into a hard consistence. In the heavier textured types there is a slight development of prismatic structure, breaking into irregular-shaped clods when disturbed. Faint colloidal stains are noticeable on the face of some of the soil aggregates. Roots that penetrate this horizon do not necessarily follow the vertical breakage planes that indicate a structural pattern. The lower subsoil is also brown but contains much segregated lime and small quantities of gypsum crystals in layers. The segregated lime also often occurs in root channels and in seams. This horizon is not so compact as the material above but there is more colloidal staining on the face of the aggregates. When disturbed it breaks into medium-sized angular clods that are easily crushed.

The light-brown or yellowish-brown underlying substratum is a friable mass with a large quantity of disseminated lime and occa-

sionally small quantities of segregated lime. It appears to be of a lighter texture than it really is until it is worked down in the hand.

The soils are extensive and are similar to the Herdlyn in parent material, mode of formation, and color, but have a somewhat less strongly developed profile. There is also some resemblance to the slightly older and darker Ambrose soils. Rincon soils are good to fair agricultural soils and suitable for a wide variety of field crops, including grain, alfalfa, beans, and flax. The compact subsoils tend somewhat to restrict use for shallow-rooted crops, although alfalfa does moderately well.

A typically developed profile of Rincon clay is as follows:

A 0 to 11 inches, dull grayish-brown clay, breaking into small irregular clods when disturbed Clods larger and firmer in lower part passing into blocky structure, the blocky aggregates separated by large cracks, which extend to considerable depth Many rootlets and small root channels penetrate this material

B_1 11 to 24 inches, a grayish-brown noncalcareous clay slightly heavier in texture or more compact than the surface soil Surface shrinkage cracks extend through this layer, giving an imperfectly developed prismatic structure There are fewer roots and insect channels in this horizon Some of the shrinkage cracks and root and insect holes are lined with dark-colored colloidal stains.

B_2. 24 to 40 inches, light-brown compact calcareous clay, breaking into irregular cubical fragments when disturbed The aggregates are heavily coated with darker colored colloidal stains. Extending into the larger cracks are a few tongues of slightly darker colored soil material. The lime is segregated in soft seams and blotches and increases slightly with depth.

B_3 40 to 58 inches, light yellowish-brown calcareous clay of irregular blocky structure The aggregates are coated with darker colloidal stains and some contain dark shiny manganese stains in the interior. The lime is segregated in seams and blotches This material is more friable than the layer above and friability increases with depth.

C. 58 to 76 inches, light brownish-yellow moderately friable and somewhat stratified calcareous clay. Lime is in part disseminated, the segregated lime being less abundant.

HERDLYN SERIES

The soil of the Herdlyn series is derived from sandstone and shale material eroded mainly from the Altamont and Kettleman soils. It occupies the central part of gently sloping alluvial fans and has a mildly developed but distinct hog-wallow microrelief. The few and relatively small bodies are eroding slightly. The profile has a strongly developed tough and dense subsoil. There is no visible lime in the surface soil, but an abundance of segregated lime carbonate is in the lower subsoil. Under virgin conditions this soil supported a cover of grasses and it developed under conditions of good drainage and low annual rainfall. It is mildly acid in the immediate surface but neutral to slightly alkaline in the upper subsoil and, as occurring in this area, it is without injurious salt accumulations. The organic-matter content is usually very low, and penetration of the dense upper subsoil by roots and water is retarded.

The surface soil is dull brown when dry but becomes richer brown when moist. This horizon is usually thin and noncalcareous and without definite structure. The soil is moderately friable and when disturbed breaks into soft irregular clods that are well permeated with root and insect holes.

The upper subsoil has a rich dark-brown color and is noncalcareous. This horizon is heavy textured, compact, and of definite prismatic structure. The prisms are approximately 7 inches long and 4 inches wide, have sharp angular corners, and are covered with colloidal stains. The yellowish-brown or light-brown lower subsoil contains considerable quantities of segregated lime in a soft nodular form. This layer is moderately compact, and there is some indication of subsoil structure. When disturbed it breaks into small roughly cubical blocks highly stained with colloids. Streaks of iron and manganese stains often follow along the cracks and line some of the small root channels.

The underlying substratum is a light yellowish brown and moderately friable, usually much lighter in texture than the horizons above. There is only a very slight compaction at this depth, and small streaks of segregated lime are observed, but the soil mass proper is noncalcareous. Roots do not penetrate this layer, which is usually dry.

GROUP 5. OLD ALLUVIAL TERRACES

The soils of Group 5 include the Denverton, Positas, and Ohmer series, all of which are probably Pedocals, although there is normally little or no free lime in the profile of the Positas and Ohmer series. They do, however, occasionally contain a little lime in the subsoil, and often some of the gravel is lime-coated. The Denverton series, the other member of this group, is definitely Pedocalic, having large accumulations of lime in the subsoil. Normally, the surface soil is noncalcareous but occasionally has some disseminated lime.

The fans or terraces on which the soils of this group are developed occur along the western edge of the San Joaquin Valley and extend the entire length of the area. The terrace materials contain many rounded particles of gravel and cobble, principally of quartzite, and hard somewhat metamorphosed sandstone and shale. The softer rocks in these old materials have mostly decomposed, leaving only the more resistant gravel. It is doubtful whether there has been sufficient decomposition of the harder rocks that now persist to make up any appreciable part of the fine soil mass. These rocks appear to be mainly outwash material from the Franciscan geologic formation or other old formations further back in the hills. Many of these terraces are underlain by bedrock, which is often exposed along the edges and slopes where drainageways have cut their way through the terrace material. The thickness of the unconsolidated terrace mantle increases from west to east. These terraces have characteristic broad flat tops and rather steep escarpment slopes. In places 20 to 30 percent of the areal extent consists of broad flat tops, the rest forming the slopes. The profile on the slopes is erratically developed and not representative of that of the flat tops.

Of the three soil series in this group the Positas and Ohmer are much alike in many features, whereas the Denverton is distinct. The Denverton and Ohmer are developed on the higher more rolling terraces and the Positas on the lower terraces.

In this group the soils have been developed in place under the prevailing climatic conditions of low rainfall, long hot rainless summers, grassland vegetation, and well-developed to excessive regional drain-

age. Internal drainage takes place slowly and is restricted by a heavy compact subsoil and in places by shallow bedrock. The water table, however, is deep and the soils do not appear to have been materially influenced by poor subdrainage.

The subsoils are dominantly of heavy texture and of prismatic or blocky adobe structure. They appear to have reached an advanced stage in profile development. The Ohmer and Positas soils are definitely Planosols; in the Denverton the high content of lime has inhibited development of the dense claypan subsoil, and the soils are much more friable and more amenable to tillage operations than most soils of similar heavy texture.

DENVERTON SERIES

The soils of the Denverton series are developed on old alluvial terrace remnants from material derived from sedimentary and metamorphosed sedimentary rocks. These unconsolidated terrace materials are superimposed on sedimentary bedrock and in some places are relatively thin.

The lower terrace remnants are dominated by gently rounded or flat surfaces from which gentle slopes descend to entrenched drainageways. The higher terraces are cut deeper by drainageways, and steeper slopes make up much more of the areal extent than in the lower lying areas. They are also more gravelly, and in many places are cut through by drainageways to the bedrock from which the soil materials are in part derived. The broad flat tops are very slightly eroded, and the slopes, although subject to some erosion, are not severely eroded and gullying is infrequent. The soil profile on the broad flats is representative of the series, but on the slopes of the higher terraces it is very erratically developed and includes wide variations within very short distances.

Despite the dominant heavy textures, the soils have excellent drainage, and both soils and seepage waters are free from alkali salts.

The surface soil is brown or dull grayish brown, and, in many places, has a rather rich-brown color when viewed across a bare or cultivated field. The soils are normally slightly alkaline but noncalcareous, of heavy texture, and usually of adobe structure. A pronounced feature is the friable character of the surface material. The blocks develop many secondary cracks and form soft aggregates that are easily crumbled into a fine friable condition even when worked under adverse conditions. They are not easily puddled and work up well under cultivation even when dry. Many roots occur throughout the surface and upper subsoil layers.

The upper subsoil is brown or rich brown calcareous and of heavy texture but breaks into soft clods when disturbed. Some mycelial lime occurs in this layer. Evidences of profile development include colloidal stains in root and worm channels and coating of soil aggregates. The surface cracks extend down through this layer, giving it a somewhat prismatic structure. Soil aggregates are a little more firm than in the surface soil, but the roots are evenly distributed and not confined to the cracks. The aggregates are permeated by many fine pores and root holes. The lower subsoil is light brown but somewhat mottled with dark-colored material from the surface, which has fallen into the cracks. These layers are highly calcareous with large soft

lime nodules. A considerable quantity of colloidal staining is on the surface of the irregular-shaped aggregates and lines the root and insect holes. Roots are not so numerous and decrease rapidly with depth. A few dark-colored manganese stains occur in this layer. Despite its heavy texture, drainage is not seriously impaired, but the normal rainfall seldom penetrates beyond this layer.

The underlying material consists of stratified old terrace materials usually containing some gravel, or the soil may rest on bedrock where the terrace mantle is sufficiently thin. Some rounded gravel usually occurs somewhere in the profile. On the lower terraces a few spots occur where the content of gravel may be sufficient to interfere with cultivation, but generally there is a much smaller quantity than on higher terraces.

The native vegetation consists of grasses and herbaceous plants, and the soils are used for dry-farmed grain and pasture. The dry-farmed areas, when summer-fallowed every other year, yield well in normally favorable seasons. Grass cover on pastured areas is usually somewhat superior to that on the residual soils developed on bedrock.

POSITAS SERIES

Profiles in the Positas series are strongly developed. These soils occur on stream benches or terraces mainly along Orestimba Creek and contain rounded quartzitic and somewhat metamorphosed hard sandstone and shale, gravel, and cobbles. This material is derived mainly from the Franciscan geologic formation occurring farther back in the hills beyond the western boundary of this area.

The benches are rather flat and gently undulating with slight irregular mounds and depressions. Erosion is slight in the flatter areas, but there is an occasional gully on the slopes. Despite heavy-textured subsoils, the drainage in these soils is fairly good, and the soil is free from mottling.

The surface soil is rich brown with a distinct reddish cast when observed across a bare field. It bakes hard on drying and breaks into irregular-shaped angular clods when disturbed. This layer contains considerable well-rounded gravel and many grass roots, yet the content of organic matter is low. The reaction is slightly acid.

The upper subsoil is slightly compact gravelly noncalcareous reddish-brown material of somewhat heavier texture than the surface soil. Some colloidal stains appear on the surface of the irregular-shaped aggregates and coat the root and insect channels. Soil aggregates are fairly firm but break down readily into a granular condition. A number of roots generally occur in this layer. The reaction is normally slightly more acid than in the surface soil. This layer is underlain by a very compact, prismatic-structured, brick-red clay layer containing very little gravel. The prisms are flat on top and bottom, 3 to 5 inches in length, and 1½ to 2 inches in diameter. They are hard and dense, with heavy colloidal coatings on the surface and have secondary horizontal cracks that cause breakage into cubes that are hard, sharply angular, and heavily coated with colloidal clay. The few roots in this layer are somewhat concentrated along the cracks.

The lower subsoil is light reddish-brown gravelly material with considerable colloidal staining. A number of dark shiny manganese stains also occur in this layer. Soil aggregates are firm but of no

consistent form, the presence of gravel masking any definite structural pattern. This layer becomes lighter in color and less compact with increase in depth. Normally it is noncalcareous, with a reaction that is nearly neutral; however, in some places the material is mildly calcareous and lime coatings may occur on the gravel even where the fine soil material is noncalcareous. Generally few roots occur in this layer.

The underlying material consists of light-brown stratified gravelly sediments, usually clay loam or clay. Although not so dense as the layer above, it is usually hard because of the gravel. Here again some of the gravel is coated and lime segregations occur a little more frequently than in the overlying material.

These soils are used mostly for pasture, principally by sheep. A little dry-farmed grain is grown, but tillage is difficult because of the gravel, and the soils are easily puddled and bake very hard on the surface.

OHMER SERIES

The soils of the Ohmer series have strongly developed profiles on old alluvial terrace materials and are probably derived from the Franciscan formation, consisting of more or less metamorphosed sandstone, shale, and conglomerate. The rounded particles of gravel are principally of quartzite and metamorphosed sandstone and shale, with a small quantity of crystalline rocks. These soils are similar in physiographic position to the Denverton but are much more gravelly. The relief is that of old terraces, with broad gently undulating plateaulike tops entrenched by drainageways. The marginal slopes are moderately steep in places but in general not so steep as some in the Denverton soils. In places near the western edge of the areas occupied by these soils the terrace mantle over bedrock is very thin. Probably because of the high gravel content, erosion is only slight on most of these soils, but there is some moderate sheet erosion on some of the steeper slopes. Gullies are infrequent. Both surface and subsoil drainage are adequate and none of these soils contains alkali.

The dark-brown or dark grayish-brown noncalcareous surface soil is fairly friable when moist but becomes very hard when dry. It breaks into irregular-shaped angular clods. Considerable gravel and some stones 6 to 8 inches in diameter are on the surface and throughout the profile. There are many grass roots but very few insect holes in this layer. Although the many ground squirrels in this area have numerous burrows in the residual and other terrace soils in the vicinity, very few such excavations are found in the Ohmer soils. This more than likely is because the soils are very hard and dense when dry.

The upper subsoil layer is rich-brown or reddish-brown noncalcareous compact gravelly clay. The upper part has a prismatic structure and the lower part is massive, with possibly a faintly developed cubical structure. The prisms are about twice as long as wide and are heavily coated with somewhat darker colored colloidal stains. The lower part of the layer is also high in colloidal staining and is very compact. Roots are not so numerous in this layer as in the surface soil but they have only a slight tendency to follow the cracks. There is less gravelly material in this than in any of the other layers.

The lower subsoil layer of reddish-brown or brownish-red moderately compact gravelly clay or heavy clay loam also shows con-

siderable colloidal stainings. It is massive in places, with few roots and no definite structure, but breaks into hard irregular-shaped clods that are firm when disturbed. The soils are slightly acid to neutral and in places some lime coatings occur on some of the gravel.

The underlying light-brown or light yellowish-brown material is friable, stratified, and gravelly and ranges from light to heavy texture. It is normally noncalcareous but some of the gravel is coated with lime. No roots extend into this layer.

These soils have a natural cover of grasses and associated herbs and are usually used for sheep pasture. The grass cover is not so dense as that on the Denverton soils but is about the same as on some of the better residual soils. Occasionally a pasture will be broken up and planted to grain as a speculation, with the hope of getting a favorable season and a profitable yield.

These soils contain considerably more gravel than the Denverton and appear to be more quartzitic and to have little if any lime. The profile is much like that of the Positas soils but much darker.

GROUP 6. FLOOD PLAINS AND BASINS

The soils of Group 6 are of the Orestimba, Columbia, Dinuba, Sacramento, and Merced series. In position, relief, parent material, and character of soil profile the Orestimba soils are intermediate or transitional between those of the flood plains and basins and those of the older alluvial fans. In drainage and land use they are more closely identified with the soils of flood plains and basins. They have developed under conditions of retarded surface drainage, high water table, and accumulation of salts and are intrazonal.

The Columbia, Dinuba, Sacramento, and Merced are formed from sediment derived from both igneous and sedimentary rocks. The first two occupy natural levees and areas next to the streams. The last two occupy shallow depressed backwater areas. The Columbia and Dinuba, being better drained and not being overflowed for so long periods as the Sacramento and Merced, are of lighter color and contain much less organic matter. The Columbia soils are without free lime and have unmodified recent profiles; the rest of the group are Pedocals with very slightly developed or very youthful profiles.

Under natural conditions the basin areas, represented by the Sacramento and Merced series, were normally flooded annually and remained under water often for several months, permitting the growth of such water-loving plants as tules and cattails.

At present, areas of these soils that are being farmed are protected by levees, but in periods of unusually high water practically all of them are flooded. The Orestimba soils are limited in agricultural use; the Columbia are suitable for a wide variety of field and truck crops, but are used mainly for grain or pasture; the Dinuba are used chiefly for grain or pasture, with a few grapes; the Sacramento are the most extensively used soils of this group, being used for truck crops, mainly celery and lettuce, and for grain, alfalfa, and pasture; the Merced soils are used mostly for pasture, with a little grain grown near Upper White Lake.

ORESTIMBA SERIES

The soils of the Orestimba series are derived from transported material originally of sandstone and shale origin. They occupy the lower

edge of the alluvial fans bordering the valley trough and have developed under conditions of poor external and internal drainage. The relief is slightly undulating, and a high water table has persisted for many years. There is some evidence of recent alluvial deposition in a few localities but no indication of active erosion. The profile has reached an immature stage of development and is distinct from any other soil profile in this area. Much of these soils contains concentrations of injurious salts. A moderate quantity of organic matter is in the upper horizons, but the profile is neutral to slightly alkaline. Under dry farming the quantity of organic matter rapidly decreases and the color becomes lighter. The surface horizon is noncalcareous, but the subsoil close to the water table contains rather large irregular-shaped lime carbonate concentrations.

The surface soil is grayish-brown and is usually shallow and moderately friable, containing many root holes and worm burrowings. The soil puddles easily when wet and bakes to a firm crust on drying after irrigation or heavy rains.

The upper subsoil is dark grayish brown and normally noncalcareous, but occasionally a few lime carbonate pellets occur. This horizon is more compact and heavier textured than the surface soil. Some cubical structure may be observed in the heavier textured types, but it is not well defined. Dark colloidal staining, pronounced on the small soil aggregates, lends a mottled appearance to the soil mass. The lower subsoils are light brown and somewhat mottled with lime and contain many lime concretions or lime carbonate pellets, which are a dirty gray and tend to accentuate the mottling of the dark colloidal staining. This horizon is slightly less compact, but the soil mass has no particular structure. This layer is very moist, as it lies directly above the more or less permanent water table.

The underlying material is light brown and is the zone of concentration of the hard lime carbonate pellets. This layer marks the general position of the more or less constant water table and may be stratified with coarse material. Frequently there are dull bluish-gray iron stains on the soil aggregates. These soils are subject to a high water table and moderate concentrations of injurious salts and are limited in agricultural use.

COLUMBIA SERIES

The soils of the Columbia series have recent unmodified profiles formed by recent alluvial deposits along the flood plains of the San Joaquin River and are derived from a mixture of sediments from granitic and sedimentary rocks. Although occurring in an area of low rainfall, much of the soil material has been transported from regions of higher rainfall. Being subject to overflow, they are receiving depositions rather than being eroded. The relief is very flat but cut-up to some extent by sloughways. The soils are freely permeable and drainage is excellent, but because of their position they are subject to a high water table a part of the year.

The surface soil is light-brown noncalcareous very friable material, somewhat mottled with iron stains and normally stratified with rather thin layers of variable-textured sediments, and contains much

mica. These layers range in thickness from a fraction of an inch to as much as 12 to 15 inches. The soils retain excellent physical properties at all times, never become puddled, and work up to an excellent tilth. The light-textured materials are of single-grained character and the heavier textured types break into soft clods of fairly low volume weight. The reaction is practically neutral.

The subsoil is more highly mottled than the surface soil and consists of similar stratified material.

In many places at depths of 30 inches to several feet, these soils are underlain by the darker soils of the Sacramento series over which they have been superimposed. This is especially true of the soils of heavier texture. Some white alkali salts occur in places, but these are readily leached out under cultivation and do not present a serious problem.

Under natural conditions these soils are covered by willows, cottonwood trees, and brush, and cut-up by many winding sloughways. Where reclaimed and protected from overflow by levees, they are farmed to a wide variety of field and truck crops. They are excellent soils but are seasonally in danger of overflow.

DINUBA SERIES

The soil of the Dinuba series is derived from mixed materials, mainly granitic sediments, but contain some material from sedimentary rock sources deposited by the San Joaquin River. It is moderately micaceous and occupies flood plain areas slightly above the Columbia. It is fairly flat but slightly undulating, probably because of slight modification of the surface soils by wind. This soil is occasionally subject to overflow, is normally free from alkali, and is light textured with a youthful profile. Drainage is free throughout except possibly in the lower subsoil, where lenses of cemented lime-silica hardpan occur. These lenses are discontinuous and do not act as an impervious layer.

The surface soil is dull-brown, brown, or light-brown noncalcareous sandy material of single-grain structureless or very soft cloddy character. It contains some mica and is nearly neutral in reaction. Roots are well distributed throughout the profile but are a little more abundant in the surface soil.

The subsoil is a little lighter in color and slightly more compact. When disturbed it breaks into soft angular clods, which are permeated by fine root pores. These aggregates crumble readily to a single-grained mass. This layer is noncalcareous except for intermittent spots near the panlike lenses occurring in the lower subsoil. The deeper panlike lenses are platy layers of somewhat heavier texture and are softly to firmly cemented in calcareous sandy material. In some places these lenses are as much as 6 inches thick and are moderately hard and compact. They are not continuous and are penetrated by some roots. The lenses occur at intervals to depths of 6 feet or more and show definite evidences of stratification, with considerable variation in texture.

Under natural conditions these soils were covered with grass and brush. At present they are used for dry-farmed grain or for vineyards.

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SACRAMENTO SERIES

The soil of the Sacramento series is derived from sediments laid down by the San Joaquin River in flat shallow overflow basins. It has its source in mixed igneous and sedimentary rocks and includes some sedimentary materials washed into basins from the west side of the valley. Though closely associated with soils of the Columbia series, it is distinguished by darker color and higher organic-matter content. In many places areas of Sacramento soil have been buried by later depositions of Columbia soil materials. The soil is still subject to overflow where not protected by levees and is being built up by deposition of sediments rather than being eroded. It is for the most part heavy textured. Drainage is restricted, the water table is fairly high, and the soil has appreciable quantities of organic matter throughout. In this area it does not contain sufficiently large quantities of salts to impair its use greatly. The relief is very flat, with some meandering sloughways and occasional ridges of lighter textured soil.

The surface soil is dark-gray or very dark-gray noncalcareous friable materials of fairly heavy texture. It is porous, has low volume weight, and contains moderately high quantities of organic matter, in places occurring as thin almost black layers throughout the profile, indicating old surfaces of buried organic matter accumulation. The lower part of the surface soil contains considerable mottling of rust-brown iron stains.

The subsoil is dull gray and in the upper part highly mottled with rust-brown stains, becoming duller with increase in depth. This layer is slightly more compact and is somewhat stained with colloids. Many of the root holes, some of which appear to extend vertically downward for considerable distances, are lined with iron stains. The subsoil is intermittently calcareous, but is most frequently calcareous where much of the soil material has been derived from the west side. The lower subsoil and underlying materials consist of stratified sediments ranging in texture from sand to heavy clay. This material is intermittently calcareous and highly mottled, usually with dull-gray or bluish-gray iron stains, indicative of arrested aeration and oxidation. Under normal conditions, this part of the profile has been below the water table for most of the time. Some of the vertical root channels observed in the layer above extend downward for some distance into this layer.

Under natural conditions these soils were covered with reeds, cattails, and other water-loving plants, with willows and brush along the sloughways. They cannot be used for farming until drained and protected from overflow. Where reclaimed they are used for a wide variety of truck and field crops.

MERCED SERIES

The soil of the Merced series is derived from river transported sediments having their source in igneous and sedimentary rocks, granitic rock material usually predominating. It occupies the valley trough, mainly in shallow overflow basinlike areas and is usually of moderately heavy to heavy texture. It has flat relief, with occasional mounds of somewhat lighter color, ranging from 1 to 3 feet higher than the surrounding soils. This soil is normally

subject to overflow, and since its relief is flat and drainage sluggish, water tends to remain long after most of the surrounding soils have dried out. This causes the vegetation to remain green during most of the summer, whereas that of the surrounding soils dries up early in summer. Because of the heavy and moderately compact subsoil and somewhat high water table, drainage is somewhat restricted. Small increments of sediments are being deposited on areas where not protected by levees.

The surface soil is dark-gray noncalcareous material that breaks readily to a soft cloddy or granular condition if worked under good moisture conditions. When dry, the clods develop numerous secondary cracks and form small but fairly firm irregular-shaped aggregates. A moderate quantity of organic matter aids in maintaining a favorable structure, and many roots extend through this layer. Reaction is about neutral.

The upper subsoil is dark-gray or black noncalcareous clay with a faintly developed prismatic structure. This layer is moderately compact but is permeated by rather evenly distributed roots. Most of the insect holes and root channels in the layer are lined with colloidal stains. Colloidal stains also coat the soil aggregates. The lower part of this layer is more massive and slightly lighter in color. The reaction is basic and often the lower part is slightly calcareous. The lower subsoil is somewhat compact calcareous dull-gray or dull greenish-gray material. Large blotches of segregated lime give this layer a mottled appearance. When disturbed this forms irregular-shaped clods that are quite firm but break apart from the soil mass more readily than in the layer above. Some roots extend downward into this layer, but they are not so numerous as in the upper part of the profile. A few gypsum crystals may occur in the lower part.

The underlying material consists of stratified dull-gray or greenish-gray sediments usually high in segregated lime and often containing gypsum. In some areas lenses and pellets of hardpanlike materials are encountered. These lenses are like those found under the Dinuba soil, and the pellets are like those found in the subsoil of the Orestimba series.

Under natural conditions these soils supported a heavy cover of grasses and small shrubs, but in some alkali areas saltgrass and other alkali-tolerant plants are found. The vegetation usually provides good pasture later in summer than most of the soils of this area. The soils are not extensive and do not occur in such large bodies as they do in many other areas and where farmed they are used mostly for grain.

EROSION [11]

Erosion is a process that removes soils and geologic materials from land surface through the action of natural agencies, primarily wind and water. A slow rate of erosion is not harmful and may even be beneficial, whereas rapid erosion is detrimental and may result in a relatively rapid deterioration of the land. Both normal and accelerated water erosion are recognized in this area.

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[11] Contributed by F. C. Eggers, associate soil scientist, and L. R. Wohletz, associate soil conservationist, Soil Conservation Service

Normal, or geologic, erosion is that erosion which is natural to the environment and not the result of man's activity. Rock-outcrop phases of several of the residual soils on consolidated bedrock have been developed by this class of erosion. These areas have little or no true soil mantle and are characterized by exposure of disintegrating bedrock. This condition is normal to this area and has not been materially induced through use of the land.

Accelerated erosion is induced by disturbance of the natural land cover through cultivation, grazing, and logging. In this area it is manifested in two forms—the removal of soil through sheet and gully erosion, and accumulation of soil materials removed from lands at higher elevation. Four degrees of sheet erosion are as follows: (1) Slight sheet erosion, representing a removal of less than 25 percent of the surface soil; this class includes the least discernible degree of soil movement and presents only a slight problem in the use of the land. (2) Moderate sheet erosion, representing a removal of 25 to 50 percent of the surface soil; the evidences of this type of erosion include occasional rills observable chiefly during the rainy season and noticeable removal of soil from plants and fences. (3) Moderately severe sheet erosion, representing a removal of 50 to 75 percent of the surface soil; erosion of this class is evidenced by frequent rills, definite profile truncation, removal of soil from plant roots, and depletion of plant cover; a problem of soil deterioration requiring immediate attention is indicated. (4) Severe sheet erosion, representing areas on which more than 75 percent of the surface soil has been removed; lands in this class are characterized by frequent rills, bald spots, color variations due to exposure of subsoil and parent material, removal of soil from plant roots, and depletion in plant cover; the advanced stage of soil deterioration indicated requires immediate attention.

Gully erosion is that type of accelerated erosion by water which produces definite channels too deep to be obliterated by normal tillage operations. Gullies are classified as to frequency of occurrence and depth. Based on frequency, the following three classes are recognized: (1) Occasional gullies, where the lateral distance between individual gullies is more than 100 feet; (2) frequent gullies, where the distance is less than 100 feet; and (3) very frequent gullying, where gullies become so frequent that they occupy 75 percent or more of the land surface. Three classes of gullies with respect to depth are as follows: (1) Shallow gullies, those that are crossable by farm machinery or, in range lands, those that are easily crossed by livestock; (2) deep gullies, or those that cannot be crossed by tillage implements and farm machinery, or in range lands cannot be easily crossed by livestock, but have not penetrated to a friable substratum; and (3) gullies that have penetrated into a friable substratum, creating a very serious condition and one difficult to control or remedy. Erosive water action in a less compact lower layer causes undercutting and results in caving and sloughing in of the upper layers. The unstable character of the substratum is unfavorable to successful installation of control structures.

During periods of more favorable rainfall or because of a change in farming practices gullies become less active and may even become grassed over to a considerable extent. These are recognized as partly stabilized gullies.

Accumulation occurs on flat bottom lands along stream channels and on the valley floor that are not normally affected by soil removal but are frequently being built up during flood periods by soil material eroded from the upland areas. These deposits may be either beneficial or detrimental, depending on the thickness and character of the alluvial material. Deposits on the valley floor of the Newman area are ordinarily nondetrimental; however, local areas of detrimental deposition occur in the uplands along streams and at the base of actively eroding hills.

Two miscellaneous types of erosion—land slips and pot holing—also occur. Land slips are typical of areas that are commonly associated with sedimentary formations in California. The term "pot holing" is used to indicate a condition of subsurface or underground channeling accompanied by frequent openings to the surface that produce a pot hole effect. As the underground channels enlarge, the undermined surface caves in and eventually results in destructive gullying. This phenomenon appears to be confined to localized areas of soils containing soluble salts.

Erosion as a factor of land deterioration in this area is influenced by a number of factors, including the nature of the soil; the slope and use of the land; and the quantity, intensity, and distribution of rainfall.

Normally about 80 percent of the annual precipitation occurs between November 1 and March 31 in the form of gentle rains that are not conducive to serious erosion. The slight precipitation from April 1 to October 31 causes little or no erosion and is of little benefit to the vegetation. Although the slope of the land varies widely only the more gently sloping upland soils are cultivated. These areas are used chiefly in the production of wheat and barley in a 2-year rotation with summer fallow and normally provide sufficient ground cover to avoid serious erosion.

The major part of the upland soils is grass-covered and is used for grazing. The hill lands south of Orestimba Creek are used chiefly for grazing by cattle while those north of the creek are used for grazing by sheep.

There are several kinds of situations in the range lands where erosion is especially severe. Severe sheet and gully erosion occur on the west slopes of the Kettleman soils in the hills adjacent to the valley from Black Gulch northward to beyond Martin Creek. The bedrock throughout this locality consists dominantly of a shattered conglomerate that is conducive to the development of deep destructive gullies. The unstable nature of the parent material allows rapid cutting and results in the development of gullies. Undercutting and sloughing of gully banks causes a rapid extension and increase in the size of gullies.

The soils in this locality are also affected by pot holes, a condition already described that tends to accelerate gully formation. These pot holes and the resulting gullies are naturally more numerous where runoff concentrates and ground water is abundant. Besides occurring in bodies of the Kettleman soils, this condition is also found in soils of the Altamont and Gaviota series. Generally where this condition exists, considerable quantities of gypsum crystals are present in the subsoil.

Immediately southwest of Crow Hill bodies of Crow Hill clay loam occur that are badly scarred by severe sheet erosion and occasional destructive gullies. Although this soil appears to be particularly susceptible to erosion, overgrazing has been a contributing factor. Extending from Crow Creek southward almost to Orestimba Creek is a ridge of Kettleman fine sandy loam, eroded steep phase, that has been subjected to a severe degree of sheet erosion with occasional large gullies.

The most erodible of the residual soils are Crow Hill clay loam and its eroded phase and Kettleman clay loam and its eroded and eroded steep phases. Other residual soils in which erosion problems are serious but which are somewhat less erodible include Gaviota fine sandy loam with its eroded phases, Altamont clay loam with its eroded phases, and Kettleman fine sandy loam with its eroded phases. Erosion on these soils ranges from slight to severe and produces gullies of all classes. In general, however, these soils are fairly resistant to erosion except where overgrazed or otherwise mismanaged, especially on the steeper slopes.

Altamont clay (adobe) with its phases, Diablo clay (adobe), and Vallecitos stony clay loam seem to be the least susceptible to erosion of the residual soils developed on consolidated bedrock. In the Altamont and Diablo clays of adobe structure, the vertical cracks are so numerous and extend so deep that practically all normal precipitation is absorbed in the soil. With runoff negligible, sheet erosion is slight and gullies are rare. Vallecitos stony clay loam is friable and throughout its profile contains numerous fragments of bedrock, chiefly hard shale. Sheet erosion on it is usually slight and gullies very seldom occur.

About half the soils on old alluvial terraces are under cultivation. Since these soils are all above the present irrigation canals, grain, in a 2-year rotation with summer fallow, is the usual crop. Almost all the cultivated acreage is on Denverton clay (adobe) although a few bodies of Positas gravelly clay loam and Ohmer gravelly loam also are cultivated. Slopes rarely exceed 8 percent, and sheet erosion is usually slight and gullies seldom occur.

On the rest of the terrace soils that are used as range lands for sheep and cattle, sheet erosion is also slight but gullies are more frequent than on the cultivated areas. The greater frequency of gullies is probably due to the steeper slopes and the concentration of runoff water in troughs and draws.

All the soils of this group—the Denverton, Positas, and Ohmer soils—may be classed as soils that do not erode readily under conditions dominant in this area.

Any plan for the control of erosion on the residual soils of the hill lands and on the soils of the higher terraces must include a program of range management with particular reference to the sheep industry in the hills north of Orestimba Creek. Too often the sheep are put on the range lands very soon after the first fall rains. This is determined not by the condition of the range but by the presence of sufficient drinking water for livestock in the small streams and water holes or by the fact that the stock can no longer be pastured on the grain and bean stubble in the valley. Too often, the pasture

is still insufficient to support livestock, resulting in an overgrazed condition, especially on the southern and western exposures, where higher soil temperatures have induced more rapid plant growth. When the heavier and more intense rains come a few weeks later the surface soil does not have enough vegetative cover to protect it. A plan of range management based on the maintenance of sufficient protective vegetative cover during the season of heaviest rainfall would be a great help in controlling most of the sheet erosion and the more shallow gullies. Such a control measure would also increase the carrying capacity of these soils.

The broad confluent alluvial fans that form most of the cultivated valley floor are occupied by members of the Ambrose, Esparto, Herdlyn, Rincon, and Pleasanton soil series of moderately developed profile, and by members of the Zamora, Dublin, Mocho, and Sorrento series of more recent accumulation and of undeveloped or feebly developed profile. At least three-fourths of the surface has a slope of 1 percent or less, and no slope exceeds 4 percent.

The soils of this group that lie above the irrigation canals are used primarily to produce grain in a 2-year rotation with summer fallow. Here the small intermittent streams are rather sharply incised and it is probable that a very slight degree of sheet erosion is occurring, particularly on slopes of more than 1 percent. Below the irrigation canals these soils are used for irrigated grain, alfalfa, orchards, vineyards, and truck crops.

Leveling, ditching, and cultural practices identified with irrigation have removed any serious susceptibility to accelerated erosion on practically all the irrigated areas.

A few of the soils adjacent to the small intermittent streams that flow out upon the fans are subject to periodic deposition of transported soil material. This is rarely if ever of sufficient depth to be harmful to field crops.

Under natural conditions before man constructed protective levees, the soils of the Orestimba, Columbia, Dinuba, Sacramento, and Merced series of the basins and flood plains were all subject to periodic overflow. Numerous bodies of these soils are still unprotected from flood and receive seasonal increments of sediment, though usually not of sufficient depth to be harmful. Where they are fully protected, they are subject neither to deposition nor to erosion. During the high water stages of the San Joaquin River in the spring and early summer of 1938, practically all bodies of these soils were covered by flood waters.

IRRIGATION AND DRAINAGE

More than 54,000 acres of this area are under irrigation in the basin and flood plain of the San Joaquin River and the lower part of the alluvial fans. Extension of irrigation to the higher levels of the alluvial fans and even to a part of the older alluvial terraces might be feasible at some future time but would no doubt be much more costly than the present installations.

The West Stanislaus Irrigation District, operating since 1920, supplies irrigation water to 19,820 acres in the northern part of this area

in the vicinity of Westley. All its water is pumped from the San Joaquin River and metered to the ranchers. The charge to the user is $3 per acre-foot, which includes a charge of 50 cents per acre-foot for new construction and lining of canals. The district has sunk a series of small test wells to a depth of 20 feet for studying ground-water conditions. In most of these the ground-water table was not encountered and in a few other instances it was found at a depth of 18 or 19 feet.

The Patterson Water Company supplies irrigation water from the San Joaquin River to about 13,000 acres within Patterson Township. This is a mutual water company and the water right is sold with the land. Each user pays $5.25 an acre and is entitled to 2 acre-feet of water. If he uses more water, the cost of the excess is prorated. Test wells show that the water table is rising within most of this district. In some of the lower lying fields, it is close enough to the surface to curtail appreciably the production of crops. No remedial measures have been attempted.

The first canal of the San Joaquin and Kings River Canal and Irrigation Company was constructed as far as Orestimba Creek in 1878. Since that time there have been a number of extensions, until at present the company supplies irrigation water to 15,640 acres in the vicinity of Newman and Crows Landing. Water is taken from the San Joaquin River at Mendota Dam. For the irrigation of grain or pasture between October 1 and April 15, the consumer each season pays $1.50 an acre. For general crops irrigated through the summer, the charge is $2.75 an acre. Grain crops require about 1.5 acre-feet and alfalfa about 4. The average quantity used in 1938 was 3.26 acre-feet an acre.

Several individual ranches pump their own irrigation water. The largest of these is El Solyo Ranch, with 4,600 acres under irrigation. Water is pumped from the San Joaquin River at a cost of about $2.50 an acre-foot. Records show that fruit trees here require 4.2 acre-feet, celery and lettuce 3 to 4, rice 6 to 7, beans 1 to 1.5, alfalfa 4, grapes 3 to 3.5, and peas 8 to 10 acre-inches. The ground-water table is not high enough to curtail production.

In the gravel beds adjacent to Orestimba Creek, several small ranches pump irrigation water from wells. Costs vary considerably, depending on the lift and the type of power used for pumping.

No organized drainage districts are within the area. Lands that need drainage are on areas of Merced, Orestimba, and Sacramento soils east of Newman and Crows Landing and in the lower part of Patterson Township.

ALKALI

The term "alkali" as used in this report refers to a harmful accumulation of soluble salts, regardless of chemical reaction. There are two types of soil alkali—white and black. White alkali is composed mainly of sodium chloride (table salt) and sodium sulfate (Glauber's salt), both of which are white crystalline substances having a neutral reaction. High concentrations of these salts in the soil are injurious in that they upset the nutritional balance, thus stunting the growth or

killing the plants. Black alkali is of strongly alkaline reaction and consists chiefly of sodium carbonate (washing soda). It has a corrosive action on plants, destroying their tissue, and a deflocculating action on the soil, causing the fine clay particles to become dispersed and the soil to become impervious to water and root penetration and to bake hard on drying. The black crust that appears on the surface of the soil affected with black alkali is caused by the sodium carbonate acting on organic matter in the presence of moisture.

Accumulations of alkali are not a serious problem in this area. There are only a few localities in which black alkali is present or where there are otherwise strong accumulations of salts. Accumulations of alkali salts occur mainly in areas of high water table, where conditions allow constant evaporation of water from the surface during dry weather, bringing to the surface the salts that are normally distributed in solution throughout a considerable depth of soil and concentrating them by evaporation of the solution at or near the surface.

Except for small quantities along drainageways in the hilly areas that have been deposited from evaporation of seepage waters, all the salt accumulations are in basin or low-lying areas, mostly along the San Joaquin River. A few small bodies of strong alkali accumulation are in the Ambrose and Rincon soils, as shown on the soil map. Most of the Merced and Orestimba soils have slight to moderate quantities of alkali. A small quantity is in some of the other basin soils, as the Sacramento and Dinuba series, and occasionally a very small quantity is in the Columbia soils. Some of the alluvial fan soils, as the Ambrose, Rincon, and Sorrento, have a small accumulation of salts in places on the outer margins of the fans where these soils border the basin areas.

Three grades of alkali accumulation—weak, moderate, and strong—are given in table 5 and are indicated on the map by symbols W, M, or A in red capital letters. The W and M boundaries are indicated by broken red lines, and A boundaries by a solid red line. Soil containing weak concentrations of alkali may be farmed to normal crops with only slight decrease in yields, but are apt to be spotty and need to be managed carefully or the alkali problem will become more serious. Areas of moderate alkali content are limited in their agricultural possibilities and are suited to a limited cropping system or pasture. They are definitely areas of marginal lands and must be carefully managed or the alkali condition will become more serious. The strong alkali areas are nonagricultural and usually form a poor pasture.

TABLE 5.—*Grades of alkali in the Newman area, Calif., and range of percentages of white and black alkali*

Grade	Symbol on map	Alkali	
		White	Black
		Percent	*Percent*
Weak	W	0.2–0.39	0.1–0.29
Moderate	M	.4–.99	.3–.6
Strong	A	1 or over	0.6 or over

Areas of white alkali can be reclaimed by flooding and leaching, provided drainage conditions are corrected and the physical properties of the soils are such as to permit ready penetration of water. Areas of black alkali can be reclaimed, but the reclamation is costly and the expense involved is seldom justified by the returns.

LABORATORY STUDIES [12]

Mechanical analyses of all the samples of surface soils were made by a proximate method in which a weighed sample was screened through a 2-millimeter sieve, the lumps being crushed, and the particles coarser than 2 millimeters rubbed relatively clean. The screened soil was shaken in distilled water with ammonia as a dispersant, then washed through a 300-mesh sieve to remove the sands, which are reported as total sands. The silt and clay in suspension that passed through the sieve was made up to volume, allowed to stand, and sampled by the pipette at proper time intervals to give effective maximum diameters of silt at 50 microns, and clay at 5 microns. The results of these analyses are not published, but were used only to check the field textural classification.

A number of samples of soils were chosen for a more complete study. Mechanical analyses of these profiles were made by the Modified International Bureau method in which a weighed sample of the screened soil was pretreated with hydrogen peroxide and hydrochloric acid to remove organic matter and carbonates. After washing free of electrolytes, dispersal was effected by shaking in distilled water with sodium oxalate as a dispersant; the soil was then washed through a 300-mesh sieve, dried, sieved, and weighed to determine the quantities of the different grades of sands. The silt and clay in suspension that passed through the sieve was sampled by pipette at proper time intervals to give effective maximum diameters of silt at 50 microns, coarse clay at 5 microns, and fine clay at 2 microns. The results of these analyses are given in table 6.

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[12] Contributed by E P Perry, junior soil technologist, University of California.

TABLE 6.—*Mechanical analyses of several soils of the Newman area, Calif.*

Soil type and sample No.	Depth	Material and diameter of particles (in millimeters)							
		Fine gravel (2 0–1 0)	Coarse sand (1 0–0 5)	Medium sand (0 50–0 25)	Fine sand (0 25–0 10)	Very fine sand (0.10–0 05)	Silt (0 050–0 005)	Coarse clay (0 005–0 002)	Fine clay (0.002–0)
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Rincon clay:									
579301	0–12	0 1	0 3	1 0	5 4	9 6	39 7	10 5	32 3
579302	12–24	[1]	2	.7	4 0	9 9	36 6	9 1	38 5
579303	24–54	[1]	3	.8	4 9	10 3	36 1	8 6	38 7
579304	54–72	.1	.2	1 3	12 5	21 9	36 9	5 2	21 7
Sorrento clay loam									
579318	0–15	1	8	2 8	11 6	17 5	33 1	6 9	26 0
579319	15–31	1	1 1	3 7	13 4	14 7	32 8	6 4	27 3
579320	31–72	.1	1 0	4 3	11 8	14 9	34 0	6 9	26 3
Ambrose clay (adobe)									
579321	0–12	[1]	1	1 8	8 7	7 4	25 0	7 0	49 2
579322	12–28	1	.5	2 0	9 3	7 0	26 2	9 5	45 1
579323	28–50	[1]	8	2 7	11 2	7 8	27 7	9 6	39 9
579324	50–72	-------	5	2 2	14 1	11 6	29 3	7 6	34 5
Pleasanton gravelly sandy loam									
579325	0–8	7 1	8 4	14 9	16 3	11 4	14 7	14 9	12 0
579326	8–22	9 1	9 2	15 1	14 0	10 6	12 1	13 3	15.9
579327	22–36	12 6	14 2	20 3	12 7	6 6	15 2	2 1	16 4
579328	36–54	14 8	17 2	26 6	14 0	4 7	9 0	3 8	10.2
Orestimba clay loam									
579338	0–7	[1]	2	1 6	10 5	17 9	39 3	7 7	23 3
579339	7–27	1	2	1 6	9 6	15 2	36 0	8 5	28 9
579340	27–45	1	1	1 7	9 6	15 5	39 6	11 3	22 6
579341	45–66	-------	.2	1 0	12 7	18 8	36 8	9 5	20 2
Orestimba loam									
579346	0–6	[1]	4	2 0	11 7	18 7	44 1	9 2	13.1
579347	6–26	.1	2	1 8	12 1	17 2	40 8	7 0	19.6
579348	26–45	-------	2	1 7	13 8	19 1	43 9	7 4	13 5
579349	45–68	-------	.1	9	8 1	19 1	48 0	7 9	14 9
Esparto gravelly sandy loam									
579363	0–12	3 6	5 3	14 4	19 7	17 2	25 3	4 0	9 5
579364	12–30	2 5	6 0	10 7	19 6	17 0	24 8	3 8	15 8
579365	30–42	5 8	7 0	16 7	18 0	13 3	21 1	3 2	15 1
579366	42–60	11 0	24 9	29 5	12 6	4.4	8 4	1.2	8.3
Altamont clay (adobe):									
579387	0–18	-------	4	1 3	4 2	3.4	20 6	8 6	61 4
579388	18–42	[1]	.5	1 1	3 9	4 0	23 0	8 0	60 0
579389	42–54	-------	.3	8	4 7	5 7	28.7	13.4	47 3
Gaviota fine sandy loam [2]									
579390	0–10	1	7	4 6	47 8	14 9	13 1	-------	18 8
579391	10–20	.1	5	3 3	42 4	17 8	17 6	-------	18 3
Sorrento loam.									
5793112	0–22	1	5	3 1	13 6	15 2	37 3	6 8	22 7
5793113	22–37	1	.7	2 7	13 0	16 2	38 8	6 9	20.7
5793114	37–66	2	5	3 5	16 0	19.9	37 0	5 8	16 3
Kettleman clay loam [2]									
5793115	0–10	2 1	4 8	5 6	18 5	9 0	28 1	-------	31 9
5793116	10–23	1 8	4.4	5 2	17 9	8 7	27 7	-------	34 3
5793117	23–32	1 6	3.8	4.7	18 3	8 2	27 2	-------	36 2

[1] Trace.
[2] Samples analyzed by U S Department of Agriculture Diameter of silt particles range from 0 050 to 0 002 millimeter

Moisture equivalents were determined by the standard method, where 30 grams of saturated soil are subjected to a force of 1,000 times gravity in a centrifuge. The moisture equivalents are reported in percentage of moisture calculated on the basis of oven-dry soil. Where the pH was sufficiently high to cause deflocculation and resultant impermeability of the soils for water, the determinations were repeated with soil cups lined with wax paper to facilitate drainage. Where drainage was satisfactory the moisture equivalent represents approximately the normal field moisture capacity or the quantity of water that is held in a soil after a heavy rain or an irrigation where drainage downward is free and uninterrupted. The results of the study are given in table 7.

TABLE 7.—*Moisture equivalents and pH values of soils from the Newman area, Calif.*

Soil type and sample No	Depth	Moisture equivalent	pH [1]
	Inches	*Percent*	
Rincon clay			
579301	0-12	24.2	7.0
579302	12-24	26.5	7.5
579303	24-54	27.4	7.8
579304	54-72	26.7	7.8
Merced clay loam			
579305	0-16	17.7	6.5
579306	16-28	[2, 3] 48.0	8.5
579307	28-38	[2, 3] 63.4	9.1
579308	38-60	[2, 3] 65.5	9.1
Columbia fine sandy loam			
579309	0-10	17.8	5.9
579310	10-26	17.5	6.2
579311	26-54	15.2	7.2
Mocho clay loam			
579312	0-15	18.0	7.3
579313	15-34	21.3	7.4
579314	34-60	26.1	7.8
Sacramento silty clay			
579315	0-12	34.5	6.7
579316	12-37	36.0	7.5
579317	37-60	16.1	7.2
Sorrento clay loam			
579318	0-15	23.0	7.5
579319	15-31	22.4	7.2
579320	31-72	23.0	6.4
Ambrose clay (adobe)			
579321	0-12	38.0	6.3
579322	12-28	35.0	7.6
579323	28-50	32.0	7.9
579324	50-72	29.8	7.8
Pleasanton gravelly sandy loam			
579325	0-8	15.2	6.9
579326	8-22	16.0	7.0
579327	22-36	14.1	7.4
579328	36-54	9.4	7.5
Herdlyn loam			
579329	0-8	15.7	5.7
579330	8-30	30.8	6.3
579331	30-42	22.9	7.7
579332	42-60	20.8	7.8
579333	60-72	14.8	7.7
Positas gravelly clay loam			
579334	0-12	17.8	5.7
579335	12-27	31.6	6.5
579336	27-54	25.4	7.1
579337	54-72	12.6	7.1
Orestimba clay loam			
579338	0-7	21.2	7.2
579339	7-27	19.3	7.7
579340	27-45	[2, 3] 25.5	8.1
579341	45-66	[3] 22.9	8.1
Pleasanton gravelly clay loam			
579342	0-7	18.4	6.1
579343	7-23	20.5	6.3
579344	23-42	19.8	6.6
579345	42-54	19.0	7.3
Orestimba loam			
579346	0-6	22.0	7.0
579347	6-26	29.8	7.7
579348	26-45	[2, 3] 39.0	9.0
579349	45-68	[3] 31.1	8.0
Orestimba clay loam			
579350	0-7	21.8	6.8
579351	7-21	[2, 3] 31.7	7.8
579352	21-36	[2, 3] 35.7	9.2
579353	36-54	[3] 20.9	8.3
Positas gravelly clay loam:			
579354	0-5	18.6	5.8
579355	5-22	17.0	5.9
579356	22-31	27.1	6.2
Positas gravelly clay loam—Continued			
579357	31-38	17.1	7.4
579358	38-54	16.7	6.1
Denverton clay (adobe)			
579359	0-6	28.1	6.6
579360	6-27	28.8	7.2
579361	27-44	29.8	7.5
579362	44-54	20.1	7.9
Esparto gravelly sandy loam			
579363	0-12	11.8	6.2
579364	12-30	13.1	6.8
579365	30-42	12.5	7.1
579366	42-60	6.1	6.8
Diablo clay (adobe)			
579367	0-8	34.4	5.6
579368	8-18	37.0	6.4
579369	18-24	32.0	7.4
579370	24-32	29.6	7.2
Dublin clay (adobe)			
579371	0-12	28.5	5.0
579372	12-32	36.0	5.5
579373	32-51	30.0	7.0
579374	51-72	34.7	6.2
Zamora clay (adobe)			
579375	0-14	27.0	6.2
579376	14-36	26.2	6.5
579377	36-54	26.6	7.1
579378	54-64	26.3	7.4
Vallecitos stony clay loam			
579379	0-4	26.5	7.0
579380	4-10	26.4	6.8
579381	10-18	([4])	7.1
Crow Hill clay loam			
579382	0-8	38.0	5.0
579383	8-15	([4])	4.1
Crow Hill clay			
579384	0-7	35.5	5.6
579385	7-15	[3] 36.2	5.1
579386	15-24	([4])	6.4
Altamont clay (adobe)			
579387	0-18	47.1	6.6
579388	18-42	41.7	7.3
579389	42-54	([4])	7.2
Gaviota fine sandy loam			
579390	0-10	17.4	7.1
579391	10-20	([5])	7.7
Dinuba fine sand			
579392	0-27	5.7	6.2
579393	27-53	[3] 14.1	8.0
579394	53-67	([6])	9.1
Mocho fine sandy loam			
5793100	0-20	17.5	7.6
5793101	20-42	[3] 20.0	8.0
5793102	42-66	20.5	7.7
Kettleman fine sandy loam			
5793103	0-14	22.1	7.6
5793104	14-34	23.5	7.8
5793105	34-44	([6])	7.8
Kettleman clay loam			
5793109	0-10	25.1	7.9
5793110	10-22	[3] 26.4	8.0
5793111	22-32	([4])	8.0
Sorrento loam			
5793112	0-22	18.8	7.1
5793113	22-37	18.6	7.6
5793114	37-66	18.4	7.8
Kettleman clay loam			
5793115	0-10	25.6	7.7
5793116	10-23	27.9	7.8
5793117	23-32	([4])	7.9

[1] By the glass-electrode method

[2] Water standing on top of soil after centrifuging

[3] Determinations made with soil cups lined with waxed paper to facilitate drainage

[4] Shale

[5] Sandstone.

[6] Hardpan.

The pH value of these soils was determined by the Beckman pH meter with the soil at saturation about 2 centimeters deep in a tall 4-ounce bottle.

Moisture-equivalent values tended to be lower than average for soils of these textures, although two were slightly high (Columbia and Gaviota fine sandy loams) ; and two others were higher (Crow Hill clay loam and Kettleman fine sandy loam. The moisture equivalent of the Altamont clay (adobe) agreed very closely with the results of the mechanical analysis by the complete method but not by the proximate.

These soils on the west side of the Great Valley, both in the trough and on the alluvial fans, are subject to influences very different from those affecting the soils on the east side. Not only is the parent material different, but deposition occurs on many confluent fans from intermittent streams that characteristically have flash floods bringing down alluvial material. The lowest lying bottom lands are under water much of the time during winter and spring, the water coming from the rains and melted snows of the Sierra Nevada to the east. The western mountains forming the source of most of the alluvial soils are composed mainly of calcareous sedimentary rocks, which are frequently also high in gypsum. The poor drainage of the low-lying soils of the area allows salts to accumulate and to permeate the subsoils. These conditions are reflected in the analyses of these soils in the laboratory. Where the water table is high, where there are sufficient salts to cause flocculation of the clays, and where added increments of soil or continuous removal of the surface soil by erosion occur faster than the weathering process, one would not expect to find much migration of colloidal clay from the surface to the subsoil.

The recent alluvial-fan soils of the Mocho and Sorrento series show very little change in clay content with depth and no change in the ratio of fine clay to total clay. The slight increase in moisture equivalent with depth in the Mocho soils seems due to geologic not pedologic factors (stratification not illuviation). These soils are continually receiving added increments of alluvial material.

Among the young and the older alluvial-fan soils, Esparto gravelly sandy loam and Zamora clay (adobe) are the only ones chosen for complete mechanical analysis. The Esparto shows an increase in clay in the B horizon over that in the A horizon, as well as a slight increase in the proportion of fine clay to total clay, but does show that a higher percentage of the clay of the B horizon is fine clay (90 percent of the total clay was fine clay). Sacramento silty clay does not show increased clay in the subsoil as judged by the moisture-equivalent data, but this is to be expected as the soil contains lime.

Most of the soils formed on the older alluvial fans that have moderately developed profiles—Esparto, Rincon, Herdlyn, and Pleasanton—have a slightly higher moisture-equivalent value in the B_1 horizon than in the A horizon. Those in which each horizon of the profile was used for the complete analysis also show somewhat increased clay in the B horizon as well as a higher ratio of fine clay to total clay. These increases are not so marked as sometimes occur in soils of similar profile development, because of the high lime or salt content that would tend to restrict the migration of fine clay. Most of these soils are alkaline in the subsoil.

The Orestimba soils of the flood plains and basins are sufficiently alkaline to restrict the passage of water, as evidenced in the determination of the moisture equivalent by the water standing on the surface of the soil after it was removed from the centrifuge. The Merced subsoil has such a high pH value (9.1) that the soil was sufficiently dispersed to restrict free drainage when moisture equivalents were run, and the cups had to be lined with wax paper to allow free water to drain away. The higher moisture-equivalent values for the subsoil, and the higher clay content as well as the higher ratios for the fine clay with respect to total clay, would all point to a certain degree of migration of fine clay from the A to B horizon, although the differences in values are not marked.

None of the soils of the hilly and mountainous area—Gaviota, Altamont, Diablo, Kettleman, Crow Hill, and Vallecitos—shows a significant change in moisture equivalent with change in depth. All are shallow and apparently erode about as fast as they weather, and thus stay in a youthful condition. The Crow Hill soils are formed from diatomaceous shales, which are slightly acid. Crow Hill clay loam has a pH of 5.0 in the surface, and 4.1 in the C_1; Crow Hill clay has a pH of 5.6 in the surface and 6.4 in the C_1. Except the Vallecitos, the other soils of this group are formed from calcareous parent material.

Mechanical analyses and moisture-equivalent determinations are used as a laboratory expression of the physical properties of the soils. These expressions, however, may be influenced sufficiently by the reaction and content of lime, gypsum, or soluble salts to alter conclusions that may otherwise be drawn. Normally the moisture equivalent corresponds closely with field moisture-holding capacity of the soil when drainage is free and uninterrupted. The mechanical analysis, by determining the quantity of clay that a soil contains, gives a measure of its heaviness. This usually correlates with the moisture-holding capacity, plasticity, friability, ease of handling, and root penetration, which emphasizes the importance of the analyses of the subsoils as well as the surface soils.

Modification of many of these physical properties, expected from the clay content, may occur where lime, gypsum, or soluble salts are present in the soil. Lime and gypsum and certain soluble salts cause flocculation of the clay and may give the appearance of a lighter textured soil. The effect of soluble salts is dependent on the nature of the salts present. Where basic salts occur, deflocculation takes place, and this makes the soil impermeable both to water and to roots.

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SOIL MAP
NEWMAN AREA
CALIFORNIA

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
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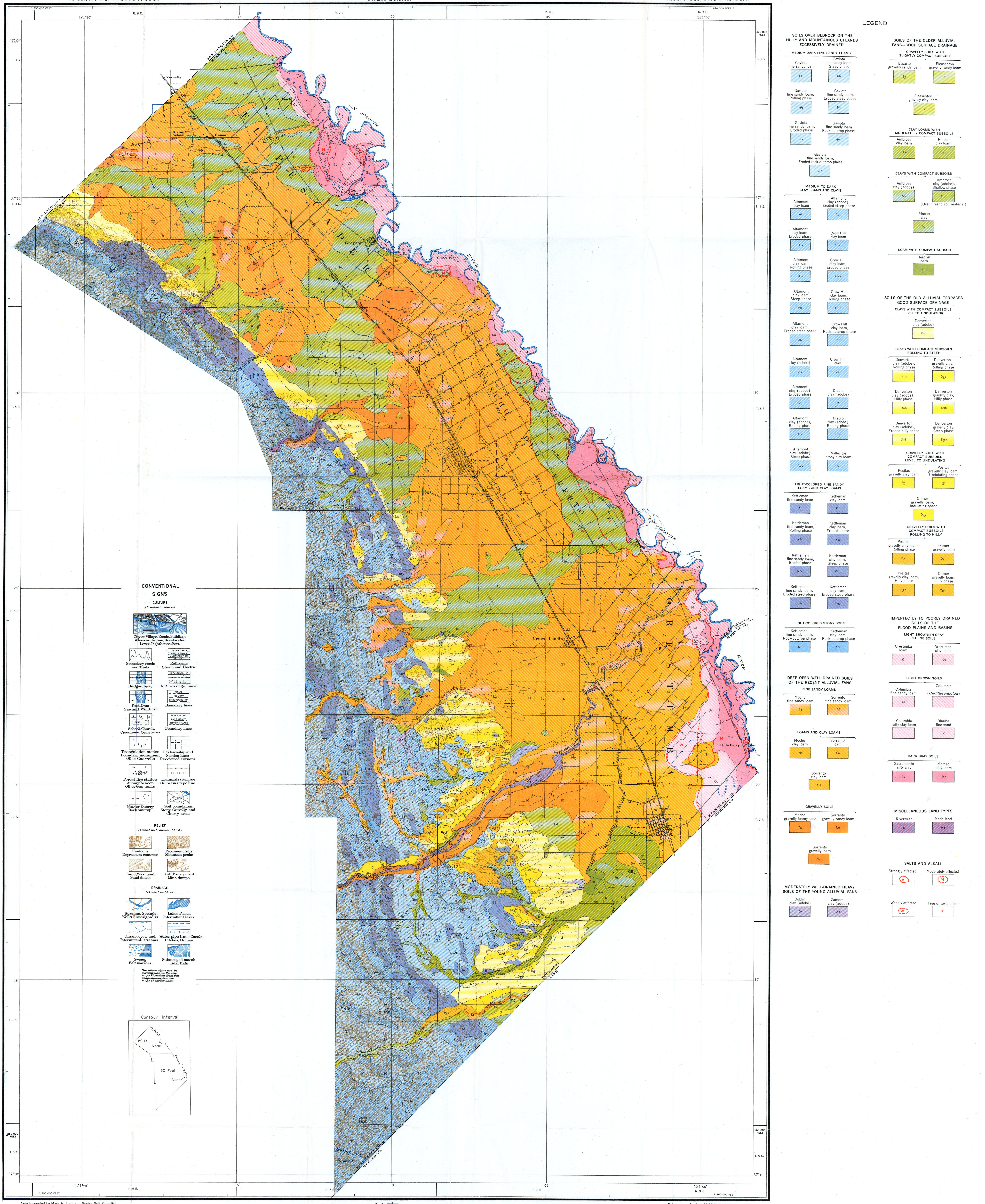

Area inspected by Macy H. Lapham, Senior Soil Scientist.
Soils surveyed by Ralph C. Cole, in charge, R.A. Gardner and Frank F. Harradine, University of California and F. C. Eggers, Soil Conservation Service.

Scale $\frac{1}{62500}$

Contour interval 50 feet.
Datum is mean sea level.

Lith. A. Hoen & Co., Inc.

Polyconic projection, 1927 North American datum.
Base map from U. S. Geological Survey Sheets.
10,000 foot grid based upon California (Zone 3) system of plane coordinates.
Surveyed in 1938. Series 1938.